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## Tail and Foot Action in the Locomotion of *Hydromantes platycephalus*

By ROBERT C. STEBBINS

SINCE the discovery of the Mount Lyell salamander, *Hydromantes platycephalus* (Camp), in 1915 (Camp, 1916), information on the natural history of this relict species has remained meager. The greatest contribution has been Adams' paper (1942) clarifying its systematic position and presenting personal observations, together with a summary of the scanty literature on the distribution, habitat, and habits of the species. Recently, I have had opportunity to study the behavior of a dozen Mount Lyell salamanders. My observations have served to reinforce earlier impressions regarding the use of the feet and tail in locomotion. The tail action appears to be unique among North American salamanders.

To appreciate the adaptive significance of the structure and action of the tail and feet, one must consider the nature of the habitat occupied by these salamanders. The species is known only from the Sierra Nevada of California to which it is probably restricted. All collection sites (7) are in the Boreal Life-Zone except for two localities in the upper Transition Zone in Yosemite, which may represent accidental distribution to lower altitudes as a result of individuals falling from precipitous places (Adams, 1942: 192).

Soil conditions, according to Adams, are remarkably similar at the collection sites, consisting of decomposed granite with little humus. Regions occupied by the species are characterized by granite rock exposures, often including both weather-roughened and glacial-polished surfaces. Talus is abundant, and rock fissures are common. Successful locomotion in the rugged habitat requires considerable climbing ability.

That climbing ability is important for the survival of the species in at least some parts of its range is suggested by the situation under which the animals occur on the top of Half Dome at the east end of Yosemite Valley, Mariposa County, California. The existence of the animals on this Boreal "island"<sup>1</sup> is made possible by the presence of a deep vertical fissure (and perhaps other fissures) at the top of the Dome. This crack is about 1½ feet wide at the surface. Its exact depth is unknown, but it is probably several hundred feet. With the melting of the snow that caps the peak (largely gone by early July), the salamanders must retreat to considerable depths to escape desiccation and overheating. The loose exfoliating shells of granite that litter the surface, although resorted to as cover when snow patches are still present, do not provide sufficient protection against drying during the intense illumination and aridity of summer. The area is almost completely barren of vegetation that might provide shade. Presumably many of the animals enter the fissure to seek levels where moisture and temperature conditions approach optimum. Water that enters the crevice from melting snow and occasional rains provides the necessary moisture. It would seem, then, that the survival of the animals on Half Dome depends, among other things, on their ability to ascend and descend the rough and smooth, variously inclined but largely vertical, surfaces of this crevice.

<sup>1</sup> They probably do not occur naturally in the Canadian and Transition zones surrounding the Dome.

During the Pleistocene glaciation, the top of Half Dome extended above the glaciers, as evidenced by the lack of striae, polish, and other marks of glacial action, but in other regions occupied by the salamanders such signs are present. It is likely that smooth glacial-polished surfaces are encountered often in the nocturnal wanderings of *Hydromantes*. Probably more than any other North American salamander save *Aneides*, the Lyell salamander is a climber. The adaptations to be discussed attest to the validity of this conclusion.

Two features are conspicuous in the habitus of *Hydromantes*: the short, blunt-tipped tail and the fleshy-soled feet with partially webbed toes. Observations suggest that both are adaptations to its peculiar habitat.

On several occasions I have observed that *Hydromantes* habitually uses its tail in a manner suggesting the use of a walking-stick, as an aid in climbing. Captive individuals crawling on an experimental board were observed carefully, with the following results: when the salamander crawls at right angles to the direction of a slope, even a very slight one, the tail is carried curved so that the tip points downhill. In this position, it is used as a supplementary hind limb, aiding in the support of the body when the foot on the downhill side is passed forward to a new position. When the new foothold is secured, the tail is lifted, curled forward, and is set down immediately behind and to the outside of the hindfoot. The series of diagrams, Fig. 1, B,<sup>2</sup> illustrate successive stages in a single completed tail movement. At 1, the left hindfoot is about to be lifted and the tail is in position to contribute stability while the foot is carried forward. Diagrams 2 and 3 show the foot moving to its new resting place shown in 4. As the body is carried forward the distance between the anchorage point of the tail and the body proper lengthens and the tail accordingly straightens. The straightening of the tail is coincident with the shift backward (in relation to the body) of the right hind limb. The impression is that the tail and right hind limb are straightening together to push the body forward. It would be difficult to determine how much actual "pushing" is done by the tail; more likely it aids principally in maintenance of balance.

Shortly after the right hind foot is lifted for movement to its new position, the tail follows. It is dragged a short distance, as shown by the track in Fig. 1, A, but finally is lifted and brought in close behind but a little outside of the left hind foot. The tip of the tail is brought against the substratum just before the foot is lifted for its recovery stroke.

That the tail is consistently used as a prop on the downhill side of a slope was demonstrated by tilting the board, on which the salamander was walking, in the opposite direction, whereupon the tail was quickly shifted to that side. Individuals could not readily be induced to walk directly up a sloping surface, but tended to veer to one side. When a direct uphill course was followed, however, the use of the tail was modified to a pendulum action, in which bracing alternated from one side to the other, with the support always present on the side where the foot was lifted.

In crawling downhill the tail movements are abandoned. When the slope is steep the animals crouch low, bringing much of the body and tail into con-

<sup>2</sup> Illustrations by the author.



tact with the substratum, thus minimizing slippage. A variety of tail movements was observed on level surfaces. Often the tail is used rhythmically on one side for a time and then shifted to the other side and sometimes back again. Occasionally it was used alternately from side to side, synchronized with the leg movements as described for uphill climbing.

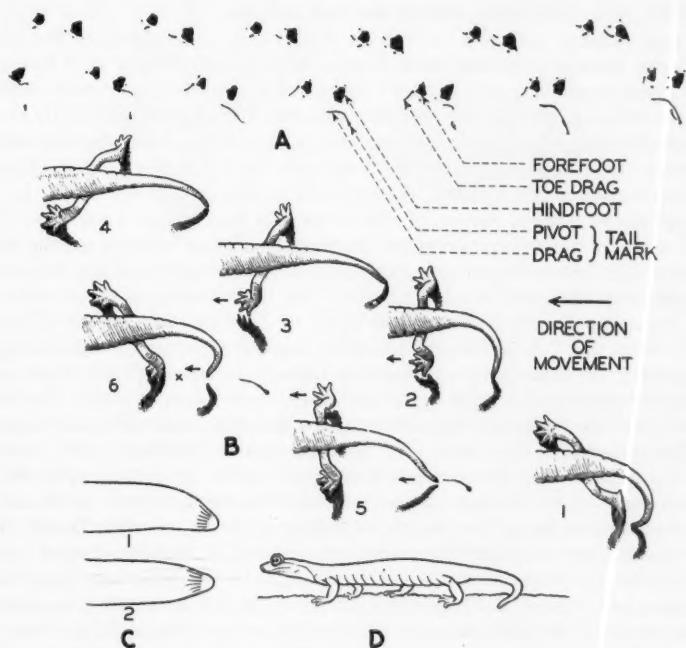


Fig. 1

A. Track of an adult male *Hydromantes platycephalus* made by allowing the animal to wallow in black ink and then walk across the drawing paper. These are the actual footprints retouched to render all marks solid black but in no way altered in shape or position. The surface of the paper sloped at an angle of 30° toward the bottom of the page. Note the position of the tail mark. The hindfoot falls behind the forefoot; there is no overstepping of the forefoot.

B. Diagrams 1 to 6 and back to 1 show successive stages (as frames in an animated film) in a single completed tail movement. By means of shadows, the relationship (whether in contact or lifted) of the hind feet and tail to the substratum is indicated. Arrows indicate direction of movement of limbs and tail. The mark to the right of the tip of the tail in diagrams 5 and 6 corresponds to that labelled "tail mark" in A. The mark "x" behind the left hind foot in drawing 6 indicates the place where the tip of the tail is to be placed against the ground.

C. Diagram 1 is a lateral and 2 a dorsal view, in outline, showing the blunt tip of the tail in *H. platycephalus*.

D. Sketch showing, in lateral aspect, the position of body and tail in a typical walking pose.

The distinctive structural feature of the tail of *Hydromantes* as compared with tail structure in other plethodonts of North America is its short, stocky nature. Musculature and nervous control are present in other genera for effective coiling and straightening of the tail. *Batrachoseps* is able to curl the tail in a watch spring coil, and I have observed vertical undulations in the tail of crawling individuals that suggest aid to locomotion by backward pressure from these undulations. In *Aneides*, the tail is somewhat prehensile

and in *Ensatina* it can be swung about accurately in striking at enemies, a capacity not based entirely on muscular control at the pelvis. The slender character and length or other characteristics, such as bulk in adult female *Ensatina*, appear to make the tails of these genera unsuited for use as a "cane" in crawling. Seemingly, in the rugged habitat occupied by *Hydromantes*, a premium was placed on tail structure, with reduction in length coupled with appropriate reflexes favoring survival.

One familiar with the habitat on Half Dome can appreciate the importance there of sure-footedness, since a fall from the vertical west face of the Dome would not only threaten the unfortunate salamander with death on the rocks below, but surviving this, also with the uncertainties of life at a lower elevation, where Lyell salamanders are rare and probably not normally present—the Transition Life-Zone. But aside from the rims of precipitous glaciated chasms like Yosemite Valley, such hazards would not occur. It is likely not so much a matter of disastrous falls that placed a premium on tail structure but rather advantages accruing from more effective locomotion in escaping from predators and adverse changes in humidity and temperature, in procuring food, and in other aspects of the life activities of the animals.

Regarding the partially webbed digits of *Hydromantes*, Storer (1925: 116) states that "the webbing of the digits suggests some degree of aquaticity in habits." So little is known about the natural history of *H. platycephalus* that this matter must await settlement later. It has been reported that *H. genei* (*italicus* of Dunn, 1926: 348) enters water prior to shedding, remaining a day or two, the skin being shed upon emergence (Bedriaga, 1897, cited by Dunn: 348), but no reference is made to use of the feet in swimming. Whether or not the animals completely immerse themselves is not mentioned.

To test the use of the feet in swimming I placed an adult female *H. platycephalus* in an aquarium where it was forced to remain in water over its depth. The temperature of the water was 23° C. After two hours the creature had expired. Even pricking with a needle did not result in so much as a tremor of the skin, although blood could be seen moving in the superficial capillaries when the skin was viewed under a binocular microscope. It seems unlikely, in view of this experiment, that the species would voluntarily enter water over its depth for any great length of time. Special attention was directed toward foot action when the animal attempted locomotion in the water. When the limbs were used, they were employed in the same manner as when walking on land, but even vigorous movements of this kind failed to move the animal progressively through the water. Effective locomotion was achieved only when tail action was employed. This consisted of lateral undulations of the tail along with sinuous movements of the body. When swimming, the limbs were extended inertly posteriorly and somewhat laterally. Poor control of balance, the fruitless "walking" movements of the limbs and continual efforts to climb out of the aquarium suggest that the animal was unaccustomed to being submerged. Certainly there seems to be little indication that the webbed digits facilitate aquatic locomotion.

Another explanation for the webbing is offered. In watching terrarium animals climbing about the vertical glass surfaces of their container, it was noted that the entire foot pad, including the webbed portion, adheres to

the glass. The moisture, both that generated by the glandular skin of the animal and that picked up as it walks about on a damp substratum, insures a vacuum seal when the air is squeezed out beneath the foot as it is pressed against the substratum. The bottom of the foot is shallowly concave when elevated (Fig. 2). The webbing increases the friction surface and insures a

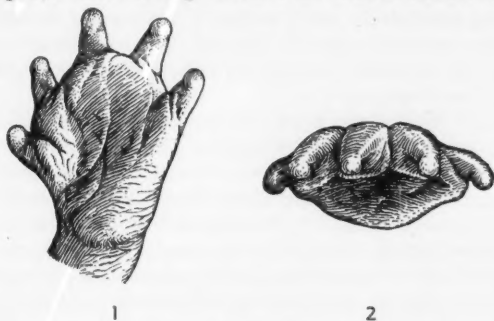


Fig. 2

1. Ventral aspect of right hind foot showing the fleshy webbing of the digits and the concave foot pad.

2. Right hind foot viewed toward the tips of the digits, showing the thick webbing of the toes.

more complete vacuum action by eliminating the air channels between the digits. The webs are relatively thick, reaching the general level of the surfaces of the underside of the foot, and they contribute to the cup-shaped character of the foot pads. The vacuum action may be enhanced by the soft fleshy nature of the non-tuberculate foot pads, in which there are a number of wrinkles. Elimination of air along these folds when the weight of the body is brought to bear on the foot would favor a firm foothold of particular value when the animals crawl over smooth glacial-polished surfaces. The structure and action of the feet is not unlike that of certain of the arboreal bromelicolous plethodonts of the genus *Oedipus* (recently revised, Taylor, 1944) of Central America.

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## Studies on a Population of Snakes in Illinois

By HENRI C. SEIBERT and CHARLES W. HAGEN, JR.

LIFE history studies of snakes, using the method of marking individuals suggested by Blanchard and Finster (1933), were recognized as offering interesting possibilities for a summer's undertaking during an interim from academic research imposed by the war. The opportunity was enhanced by the proximity of a defunct subdivision in which previous casual surveys had indicated an abundance of snakes.

The area so studied was a typical flat, uncultivated field in the Lake Calumet region of southeastern Chicago. The plot was roughly a long trapezoid, the long axis running northwest and southeast, bounded on one side by a cement sidewalk elevated about 2 feet above the level of the field. There was a 3 to 4 foot drop to an adjacent field on the other side of the sidewalk. Approximately 60 yards in the opposite direction there was a drop of 3 to 4 feet to another field, giving the impression that the upper level had at one time been filled in. On the southeast boundary was a much travelled highway, and at the northwest end were a shanty and some cultivated plots. A rarely used dirt road ran in the same direction as the sidewalk, at a distance of 10 to 22 yards from it. The survey did not cover the entire field but was confined to a strip 390 yards long between the sidewalk and the road, plus an additional area 20 yards wide on the other side of the road. This gave an area of 15,600 square yards, or 3.2 acres (13,043 m<sup>2</sup>).

The principal vegetation in the southeastern half was white sweet clover (*Melilotus alba*), which reached 5 to 6 feet at the height of the growing season in July and August. In the northwestern half, the sweet clover was in smaller stands, interspersed with large patches of bouncing bet (*Saponaria officinalis*), occasional thistles, and several species of grasses. In the fall the cover was largely of *Aster*, stalks of *Melilotus*, sunflower (*Helianthus annuus*), and ragweed (*Ambrosia* sp.). Grasses were most common along the edges of the road. The larger plants were the common cottonwood (*Populus deltoides*), tree of heaven (*Ailanthus altissima*), and matrimony-vine (*Lycium halimifolium*); these, however, were very sparse and did not anywhere constitute a dominant cover. Small victory gardens had been planted early in the season, but later abandoned, at three different spots within the area. In the spring, the adjacent fields on the lower levels were inundated and maintained some amount of water for the greater part of the season.

On May 20, 1945, the area chosen was mapped out and systematically combed for snakes every week thereafter. The larger rocks and bricks, pieces of metal, cans, boards, tarpaper, and miscellaneous debris that had accumulated over a period of years were lifted up and carefully returned to their original positions. Our arbitrary boundaries were selected because the principal cover was adjacent to the road and the vegetation was too dense to expect to find any snakes that were not under cover; there was no object in attempting to census the entire upper level. Captured snakes were marked by clipping the caudals in various combinations for future identification, measured to the nearest one-eighth inch with a cloth tape, sexed, and released at the immediate point of capture, which was then recorded on the

map. The last survey was made November 4 when all snakes appeared to have hibernated for the season.

#### TOTAL POPULATION AND ITS FLUCTUATION WITH THE WEATHER

Of 383 snakes marked, 298 (77.8 per cent) were the plains garter snake (*Thamnophis radix*); 78 (20.3 per cent), the smooth green snake (*Ophiodrys vernalis* ssp.<sup>1</sup>); and 7 (1.8 per cent), the common garter snake (*Thamnophis sirtalis sirtalis*). Since the number of common garter snakes was so small, they have been eliminated from all the subsequent data on *Thamnophis*.

The total number of snakes captured each week is plotted in Figure 1. Except for the small numbers on June 17 and 24, and again on July 15, the trend for *Thamnophis* showed a gradual decrease in numbers from May to the end of September. An increase in October (see Fig. 1) was followed by a complete disappearance on November 4. There was initially a similar decline in the number of green snakes, but after the end of June a steady small population persisted until irregular increases occurred in the fall. These final population increases were due to the appearance of newly born or newly hatched young.

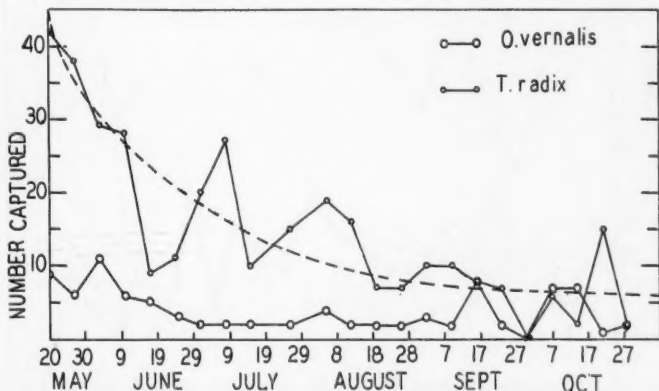


Fig. 1. Number of garter snakes and green snakes collected each week. Broken line represents logarithmic curve fitted to the garter snake data.

The totals per month were: May, 80 (2 collections); June, 77 (4); July, 72 (4); August, 49 (4); September, 35 (5); and October, 25 (4) for *Thamnophis* and 15, 25, 8, 10, 15 and 17 respectively for *Ophiodrys*.

An attempt was made to correlate the fluctuations in numbers of garter snakes collected with weather conditions. The daily mean, maximum, and minimum temperatures, and the total precipitation were plotted against the weekly totals of snakes captured. No definite relationships were found. However, when the temperatures were plotted against the deviations from the best fitting logarithmic curve (broken line in Fig. 1), some interesting correlations were found. These deviations are plotted in Figure 2, together

<sup>1</sup> Two males that were collected had the following scale counts: ventrals, 131 and 133; caudals, 85 and 85.

with the maximum and minimum temperatures during the collection period. A slight correction was made in the second week's collection because of an interruption caused by a sudden fierce rainstorm so that instead of the actual 38 collected, it was estimated that 50 would have been found on the basis of the ratio of area completed to that not completed. The graph clearly indicates that when the mean temperature fell below 70° F., there were negative deviations from the predicted number of snakes. There is some indication that when the temperature rose above 85°, the number of captures was also lower. After the first week in October the relationship no longer held as the snakes began retiring into hibernation and many new-born snakes were found. No snake was found on November 4 when the temperature had fallen to 40° at the time of collecting, the coldest of the season. On the hot days the snakes left their cover and on several occasions were seen basking in the sun, although it was thought probable also that many retired to cooler spots underground. In either case their capture would not have been possible and hence the lower totals for those days. On cold days they likewise repaired underground where the soil was warmer.

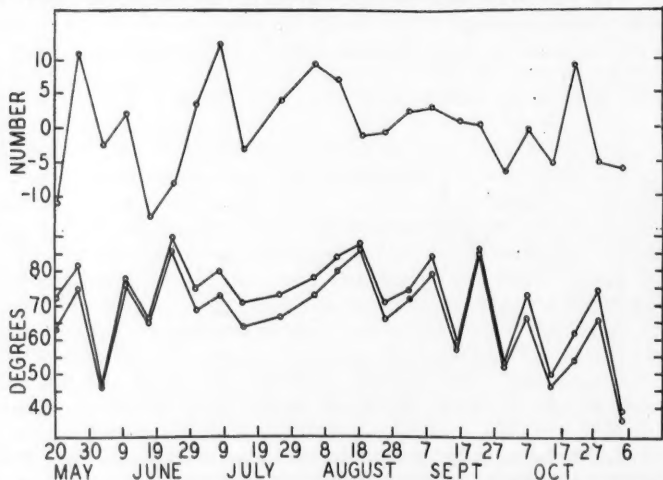


Fig. 2. Relation of garter snakes captured to temperature. Upper curve, deviations of total collected from predicted number. Lower curve, maximum and minimum temperatures during collection period.

Lueth (1941) found that at air temperatures between 50° and 86° F. the rectal temperature of snakes was nearly equal to the external temperature. Above 86° the snake's temperature was lower, while below 50° it was higher. This would indicate optimum adjustment to be within 50-86° and that beyond those limits zones of physiological disturbance are avoided by the snakes whenever possible by retreating underground. This would explain the relatively low number of snakes caught on days above 85°. On the other hand, we found that down to 45-50° some snakes still ventured out, but that none were found at 40°.

#### SEX DISTRIBUTION AND RATIOS

Whenever the size of the snake permitted, the sex was determined. *Thamnophis* under 12 inches and *Opheodrys* under 9 inches were usually too small for reliable sexing by external characteristics and sufficient time was not available to permit more refined methods. Hence the sex data are not for the entire population but only for individuals over the limits indicated. Sexing was not begun until after the second week; any sexed individuals appearing prior to that date, or under the size limits indicated above were sexed on recovery. Fifty-seven per cent of the 217 *Thamnophis* sexed were females and 65 per cent of the 51 *Opheodrys*; thus there were 75.0 and 54.5 males per 100 females respectively.

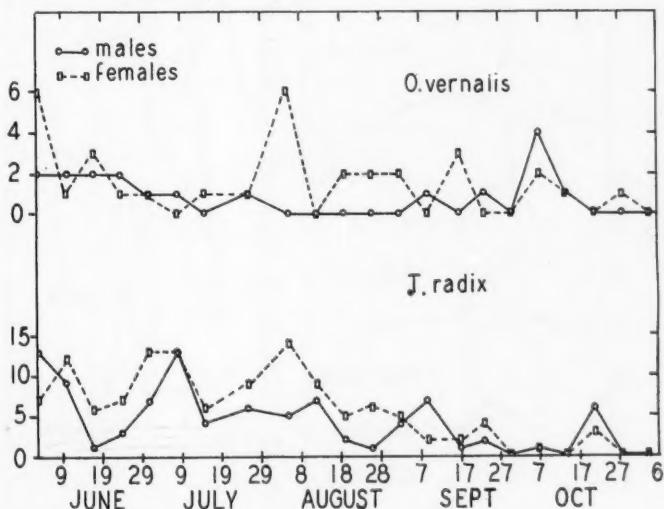


Fig. 3. Weekly totals of males and females collected.

The weekly totals of males and females captured are shown in Figure 3. The females outnumbered the males on the majority of collecting dates. On August 5 the females greatly outnumbered the males and since this occurred for both the garter and green snakes on the same date, it is possible that it has some significance. Blanchard (1937) found a similar relation in the red-bellied snake (*Storeria occipitomaculata*), in which the sexes were approximately equal except from July 17 to August 7, when he found 53 females to 20 males. He suggested that the females seek the sun before the laying period. This cannot be the complete explanation, however, as the great majority of the females that we found on August 5 were not sexually mature.

#### SIZE AND AGE DISTRIBUTION

Figure 4 presents the size frequency distribution of *Thamnophis* grouped in bi-weekly totals (with the exception of October). Inspection shows two major size groups at the beginning of the season: one of 10-12 inches and one



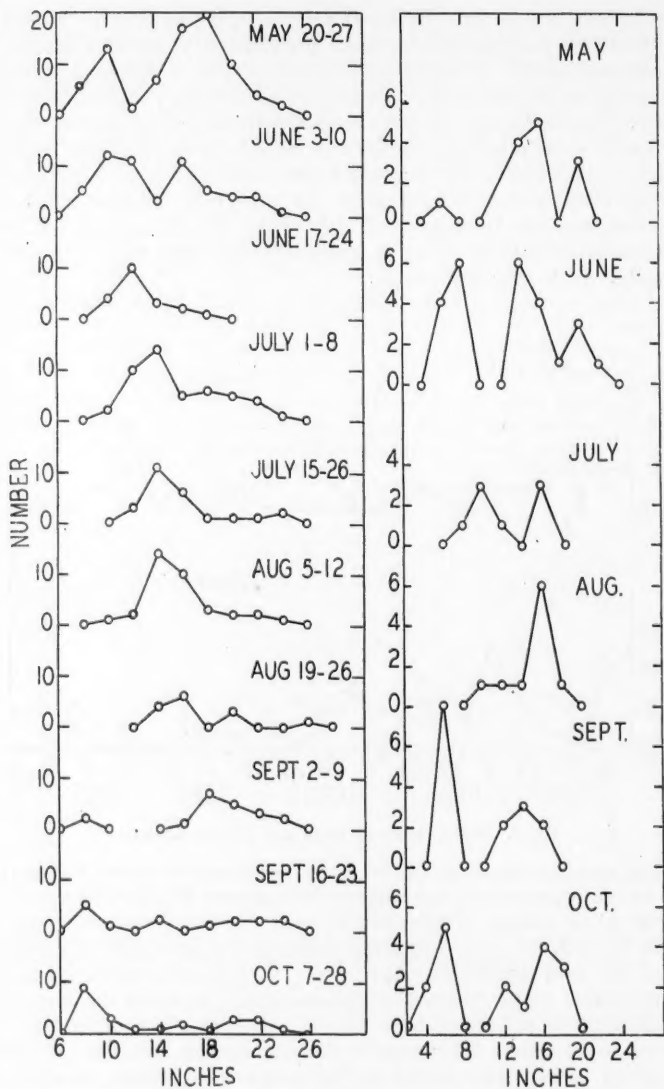


Fig. 4. Size frequency distribution of the garter snakes (left) and the green snakes (right).

of 16-18 inches. To the first group belong those born the preceding fall, while the second contains those in their second spring season. The growth of the former group can easily be followed throughout the season, culminat-

ing around 18 inches at the end of the year. The larger snakes, with the exception of occasional stragglers, disappeared as a major group as the season progressed.

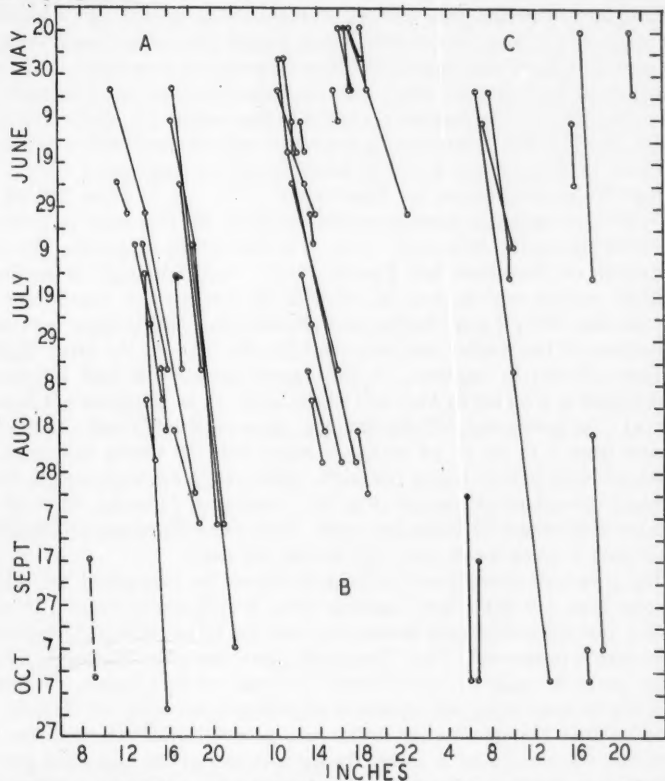


Fig. 5. A. Growth in recovered male garter snakes; left, one-year old; right, two-year old. B. In female garter snakes; left, one-year old; right, two-year old. C. In green snakes; left, one-year old; center, two-year old; upper right, three (?) year old.

If a straight line is drawn through the *Thamnophis* curves from the 10-inch group in May to the 16- or 18-inch group in October, it will pass through the majority of high frequency peaks. This gives an increment of 6 to 8 inches over a period of 112 days or 16 weeks, that is, from May 20 to September 9, the last date to show a definite high frequency peak. The growth rate is then 0.44 (.37 to .50) inches per week. Confirmation of this value was found in measurements of individually recovered snakes (Fig. 5). For a total of 23 snakes that were recaptured after one or more weeks and which were apparently in their first year of growth, the average rate of growth was 0.45 inches per week. Were the slope extended to the end of the season, it would end at 20 inches, but this leads to an inconsistency since the spring data show that two-year snakes average only 16-18 inches. There

must have been a decrease in growth rate at the end of the season, or the season studied was not comparable to the preceding.

This point was further tested with recovered snakes. Those captured during May, June, and July had an average rate of growth of 0.62 inches per week, while those recaptured during August, September, and October averaged 0.36 inches per week. When considered on a monthly basis, the growth rates in inches per week were as follows: May-June (12 snakes), 0.47; July (8), 0.77; August (11), 0.49; September (5), 0.45; October (3), 0.15. The five recoveries in September all occurred within the first nine days of the month. It would therefore appear that in the vicinity of Chicago the growing season for *Thamnophis radix* extends from the end of May (perhaps earlier in more favorable years) to the first week in September, declining rapidly thereafter. This is in substantial agreement with the observation of Blanchard and Finster (1933) that "although in northern Michigan snakes may be seen on occasion in October and April, there is evidence that little, if any, feeding and growth take place in these months."

Because of the smaller numbers available the data on the green snakes are more difficult to interpret. A line drawn through the high frequency peaks begins at 6 inches in May and continues to 15 or 16 inches in October (Fig. 4); the spring and fall distributions agree reasonably well. If the increment from 6 to 14 or 16 inches is taken over 16 weeks, the rates of growth are 0.50 to 0.63 inches per week. However, growth appears to have continued throughout the season (Fig. 5c), a period of 24 weeks, which gives the rates of 0.33 to 0.42 inches per week. Data from recoveries of first-year snakes gave a much lower rate, 0.28 inches per week.

The growth of second-year<sup>2</sup> individuals cannot be determined with great accuracy from our data; first, because there is evidence of overlap in size between the age groups, and second, because the larger snakes disappeared as the season progressed. The *Thamnophis* two-year olds, starting at 16-18 inches, probably grew to 22-24 inches at a rate of 0.37 inches per week. When the growth curves are separated according to sex (Fig. 6) there is an indication that the second-year males were predominantly 16-18 inches in length and the females 18 or more. By the first of July the males had grown to 18-20 inches and the females to 20 plus. By the end of the season, the males were 22 inches and the females 22-24. Among the recoveries, the rate of growth was 0.39 for first-year males and 0.54 for first-year females; during the second year the rate was 0.30 for males and 0.72 for females. The latter rate is high and may be accounted for by the fact that all second-year females were caught within the first six weeks of the season when growth was most rapid.

A third excursion in the May curve is produced by the 22-inch males and 24-inch females and is possibly significant. If these represent third-year individuals, they would account for the 26.2-inch female caught in August, the largest specimen we found.

The green snake is a smaller species, yet individuals entering their second year were about the same size as the garter snake two-year olds. The

<sup>2</sup> We refer to the individuals that have passed one winter as "first-year" snakes and to those that have passed two winters as "second-year" snakes.

rate of growth during the second and succeeding years must necessarily be slower. Figure 4 indicates that the 16-inch group barely grew in length. Our largest specimen, a 22-inch female, was caught June 17. Again the problem arises whether this was a two- or a three-year old. The larger green snakes showed a bimodal distribution (Fig. 4), the right-hand mode consisting of females. The left-hand mode consists of both males and females throughout May and June, and of females alone throughout July, August, and September. In other words, while the males averaged 14 inches and

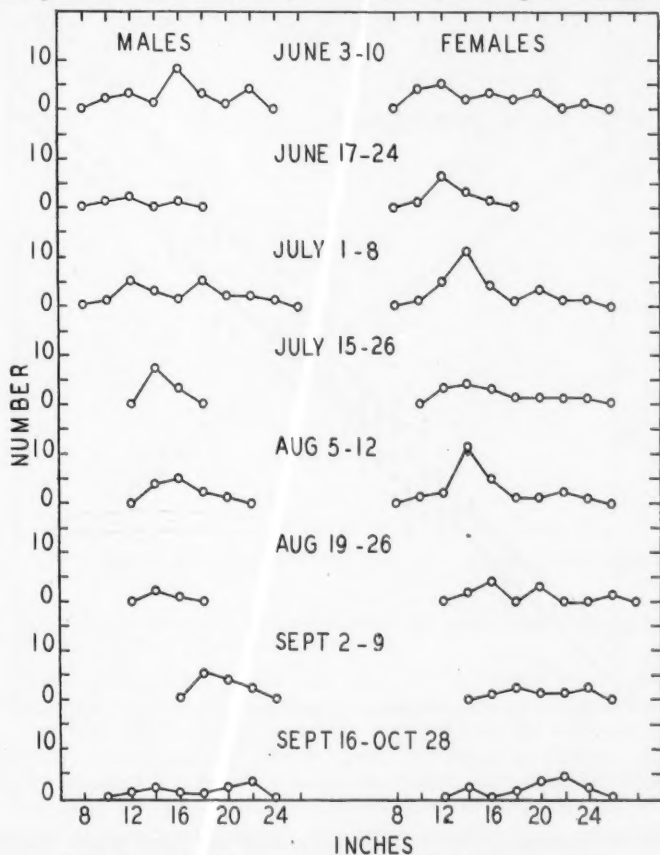


Fig. 6. Size frequency distributions of male and female garter snakes.

the females 16 in May and June, the males dropped out as the season progressed and the females did not grow appreciably, since at the end of the season they were only 16-18 inches long. Hence it must be concluded that the 20-inch females in the spring were in their third year, which group might therefore include the above-mentioned 22-inch female.

From these data, young garter snakes grow 50-60 per cent of their length

at birth in the first year, males 25-37 per cent and females 33-37 per cent in the second year, and females 8-15 per cent in the third year. Green snakes grow 150-170 per cent the first year and perhaps 37 per cent the second. Blanchard and Finster (1933) state that young snakes (*Thamnophis sirtalis*) grow 30-40 per cent the first year and "adults" 5 per cent per year. Their record of the release of a 192 mm. (7.5 in.) snake that was recovered one year later at 247 mm. (9.7 in.) in length cannot be considered typical. Equally surprising was a female 530 mm. (20.8 in.) that 11.5

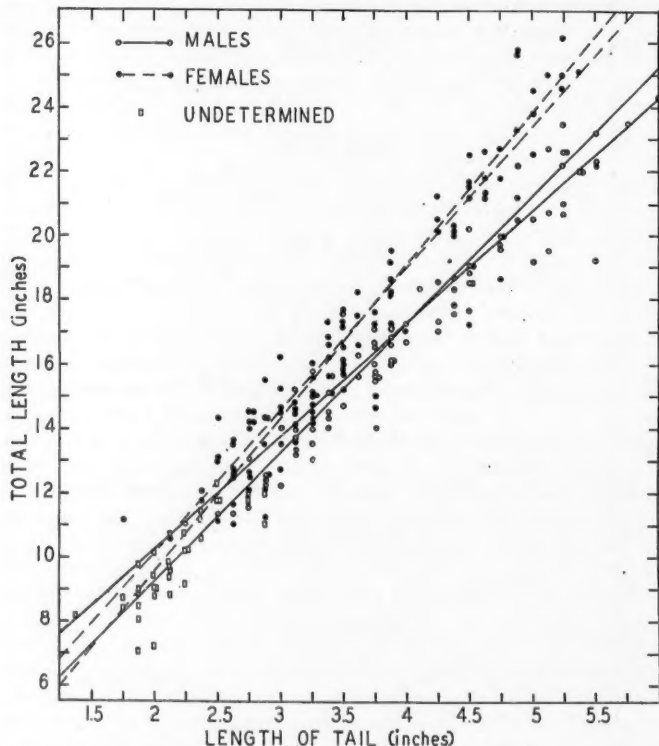


Fig. 7. Scatter diagram of total length against tail length in garter snakes. Regressions fitted by least squares to sexed individuals only.

months later measured 685 mm. (27 in.). After two years and 11 months, a male and female had grown from 550 mm. (21.6 in.) to 638 mm. (25.1 in.) and 600 mm. (23.6 in.) to 643 mm. (25.3 in.) respectively. If these recoveries were all correctly identified, the rates of growth must vary considerably among individual snakes.

#### RELATIVE GROWTH OF TAIL AND BODY

Ruthven (1908) states that in *T. radix* "the tail length is quite consistently about .23 to .26 in the males and .20 to .23 in the females." Burt

(1928) found quite an overlap in the tail to body ratio for *T. sirtalis*. The female ratio ranged from 18.8 to 25 and male ratios from 22.1 to 30.8, the overlapping group including 56 per cent of the observations. In neither paper were the sizes of the snakes given.

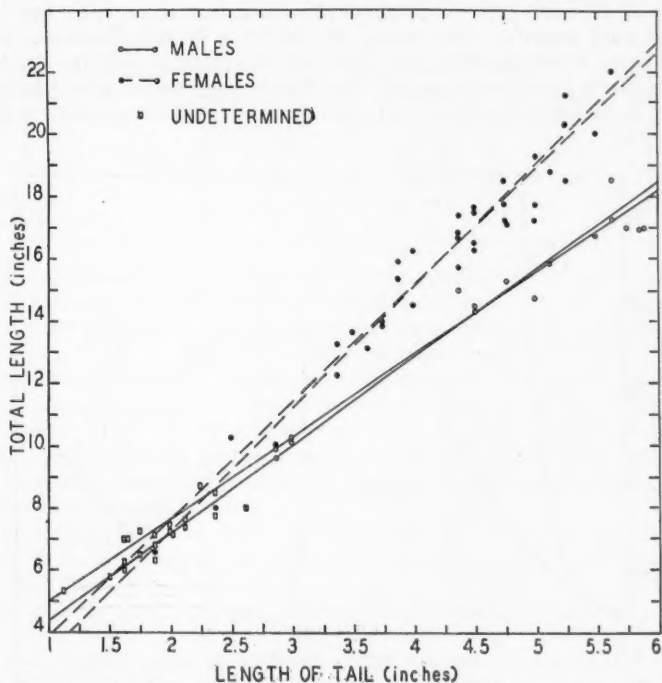


Fig. 8. Scatter diagram of total length against tail length in green snakes. Regressions fitted by least squares to sexed individuals only.

In measuring snakes in the field we found less possibility of error in measurement of the tail because of its lessened power of contraction and the ease with which it could be held motionless against the tape. Consequently, total length was plotted against tail length in Figures 7 and 8, rather than against tail-body ratio, which would repeat the errors incurred in measuring the body. Straight lines were fitted by the method of least squares for males and females. The following regressions were obtained, where  $x$  = tail length and  $y$  = total body length, in inches.

$$\begin{aligned} \text{Thamnophis males } y &= 3.17 + 3.50x \\ x &= -.33 + 0.25y \\ \text{females } y &= 1.24 + 4.43x \\ x &= 0.07 + 0.20y \end{aligned}$$

$$\begin{aligned} \text{Opheodrys males } y &= 2.35 + 2.65x \\ x &= -.63 + 0.36y \\ \text{females } y &= 0.13 + 3.76x \\ x &= 0.15 + 0.25y \end{aligned}$$

In garter snakes below 15 or 16 inches the sex differences in tail to body ratio are not readily apparent, but the divergence becomes more

pronounced with the growth of the snakes. In green snakes a more discrete separation appears at an earlier age. Just when the sex difference first appears can be determined only by measuring young snakes and following their growth. If the regressions are plotted as total length against tail-body ratio (Fig. 9) it is at once apparent that the females' tail and body grow at the same rate. The tails of the males grow much faster than the body until maturity, after which the difference in rate decreases. This rapid rate of tail growth in the males may be correlated with the development of the reproductive system. The female green snakes grow relatively more in the body than in the tail when compared with female garter snakes (Fig. 9).

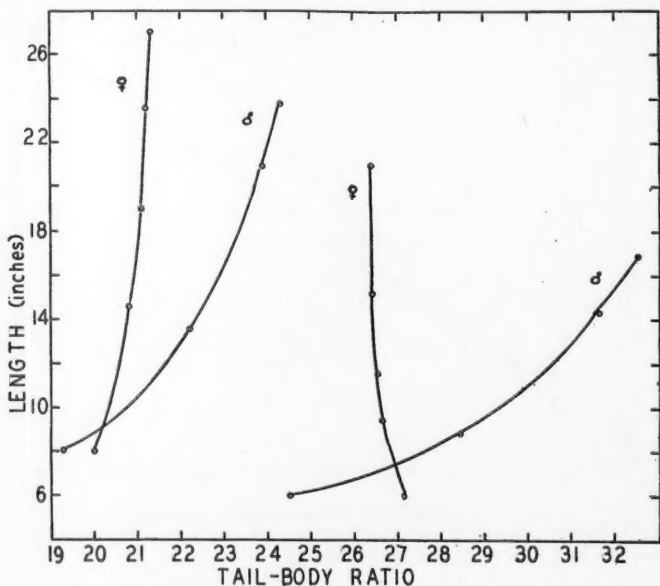


Fig. 9. Relation of tail-body ratio to size in garter snakes, left, and green snakes, right.

#### LOCAL MOVEMENTS

Of 298 garter snakes marked, 41, or 13.8 per cent, were recovered after one or more weeks. Twelve out of 78, or 15.4 per cent, green snakes were recaptured. No common garter snake was found a second time. The ratio of males per 100 females of recoveries for *Thamnophis* was 77.2, a close agreement with the ratio observed for the total population. The ratio in *Opheodrys* was 33.3, much lower than for the total population, but the total recoveries were small. The percentage of recoveries by weekly periods is shown in Figure 10.

The most impressive feature of the recovery data was the small distance travelled by the individuals recovered. The points of release and recapture



were marked on our maps and a straight line connecting the two points was considered to be the total distance travelled. The possible error in this method is obvious but no other way was available to record the daily wanderings. The frequencies of snakes that travelled various distances from the point of release in yards and in yards per day are given in Table I.

TABLE I

Yards	<i>T. radix</i>	<i>O. vernalis</i>	Yards/Day	<i>T. radix</i>	<i>O. vernalis</i>
0- 4.9	9	0	0-1.9	34	9
5- 9.9	10	5	2.0-3.9	3	2
10-29.9	11	5	4.0-5.9	2	0
30-49.9	4	1	6.0-7.9	1	1
50-99.9	6	0	8.0-9.9	1	0
100 and over	1	1			

Almost half of the individuals travelled less than 10 yards between captures, but what is more significant, travelled less than 2 yards per day. Four garter snakes were recaptured twice, and one individual was recaptured four times. Only 2 green snakes were recaptured more than once. The longest interval between captures was a garter snake marked on June 3 and recovered on October 7, 59 yards from the point of release. Mapping was subject to an error of 1 or 2 yards. Since the cover under which the snakes were found was always recorded, certain individuals were definitely known to have been recaptured at the identical point of release. Four such recoveries were made, one after an interval of six weeks.

Garter snake No. 54, which was recaptured four times, had moved 17 yards in two weeks before the first recapture, and 7, 5, and 3 yards in the following three weeks. When last seen on the fifth week, it was actually only 12 yards from its original location, having travelled in a semicircular arc.

The question arises as to whether snakes wander indiscriminately or have definite territories like those of birds and mammals. Blanchard (1937) found no red-bellied snakes the year after they were marked, but within the same year he recovered one female  $\frac{1}{4}$  mile away 24 hours after release and recovered the same snake the next day "not quite so far away," and three days later at the same place of the second recapture. An adult male was recovered seven days later 100 feet away. Blanchard and Finster's table of recovered common garter snakes shows movements up to 5 miles after a period of three years. It appears that no attempt was made to release the majority of the snakes at the point of capture, consequently a home range cannot be proved or disproved from their data. Noble and Clausen (1936) found that *Storeria dekayi* remained in the region where they were released providing they were originally found there, and if they were released in a locality some distance from where they were found they often returned to the original location. Of 32 snakes marked and released in a foreign territory, 13 returned to the original spot over a 70-day period. Eight wandered 1320 yards in one week. Other recoveries (5, April to October; 6, October and November) indicated random movement during

summer and early fall, and a migration to hibernating regions in October and November.

The fact that none of the recovered snakes had wandered very far in our area may mean only that the individuals that had not moved to any great extent were those recaptured in our studies, and that the others had moved from the area. However, that they could not have wandered very far is indicated, as some marked in May were recovered in August and October and others marked in June were recovered in September (Fig. 5). This could be interpreted as meaning that some snakes were returning to the area to be near their hibernating places, which may have been under the sidewalks. On the other hand, the disappearance of the majority of the second-year snakes after the middle of June did not necessarily indicate a movement from the area. Because of their larger size, these snakes may have had less ability to hide under small cover and hence found hiding places less accessible to us. Figure 5 shows that first-year and second-year males remained to some extent within the area, but that the females disappeared either by migration or by hiding, as few were recovered after any long intervals of time, and no second-year females were recovered after July 1.

Females were found to average more yardage than males, 1.15 yds./day vs. 0.79 yds./day in *Thamnophis*, and 1.44 vs. 1.20 yds./day in *Opheodrys*. When further broken down according to age, the first-year males of *Thamnophis* travelled 0.81 yds./day to the first-year females' 0.88, and second-year males travelled 0.78 yds./day to the females' 1.73. In *Opheodrys* the first-year females travelled 0.12 yds./day and second-year females 1.23. Snakes recovered during May, June, and July averaged 2.0 yds./day and 1.26 yds./day for *Thamnophis* and *Opheodrys* respectively; those recovered in August, September, and October averaged 0.49 and 0.27 yds./day respectively. When broken down on a monthly basis, the average yds./day travelled by *Thamnophis* recoveries were: May-June, 2.0; July, 2.0; August, 0.42; September, 0.44; October, 0.59. These data indicate that there is a spring dispersal more pronounced in adults than in first-year individuals, and most pronounced in the females.

Noble and Clausen noted that during June and July, adult males and half-grown individuals of *Storeria dekayi* were always found in the grass and actively wandering around while adult females were always found isolated under stones or paper. The females went into seclusion during the last part of the gestation period and remained in one locality until parturition. If *Thamnophis* females behave in the same way they must isolate themselves in inaccessible places, probably in underground cavities.

On several occasions the area surrounding our plot was searched for marked snakes. Although over 30 snakes were found in the course of the season outside our boundaries, none had been marked.

Twice both species of *Thamnophis* were found under the same cover and several times *T. radix* and *Opheodrys* were found together. No aggregations were found with the exception of 5 *T. radix* under a piece of tarpaper on October 21.

#### AGE AND REPRODUCTION

The population of garter snakes as judged by size, exhibited an age distribution as follows: 52.7 per cent referable to their first year, 34.6 per cent

to their second, and 12.6 per cent to their third. In view of the facts that no females were found pregnant in the first-year size group, and that in related species, *sauritus* and *sirtalis*, no embryos were found in females under 22 and 24 inches (Burt, 1928), it is believed that *radix* does not breed until the second year (i.e. the second spring). This means that roughly only 50 per cent of the total population in the spring were potential breeders. The number that actually do breed is not known, although Burt found that over half of the female adults (those over 24 and 22 inches) of *T. sirtalis* and *T. sauritus* examined did not bear young. The age distribution in the green snakes was 31.0 per cent, 55.1 per cent, and 13.8 per cent for first-, second-, and third-year snakes. These results are difficult to explain and although the percentage of third-year snakes agrees with that of the garter snakes, the other two age groups are approximately reversed. This is probably an error due to the small numbers collected.

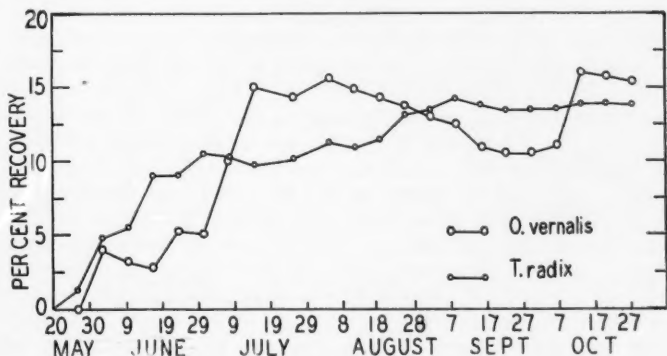


Fig. 10. Accumulated recoveries, in per cent of total-marked, for each week of collecting.

The total population of snakes in the area would be a useful statistic in determining mortality rates, replacements, and densities. Unfortunately no safe approximation of this figure can be derived from our data. After eliminating young of the year, the total snakes marked were 278 *T. radix* and 65 *O. vernalis*. Although the numbers of new snakes diminished (not including the newly born) as the season progressed, the percentage of recoveries did not increase as would be expected if the total population were being sampled. The area studied, as already indicated, was sufficiently surrounded by barriers to impede free and easy access to snakes and to circumscribe the population to a certain finite number. As only half of this area was surveyed, individual snakes may have wandered at will between the two areas; nevertheless, there would necessarily be a period when those wandering in would be in equilibrium with those wandering out, at which time the percentage of recoveries would rise. But each week the proportion of new snakes was as large as the preceding week (Fig. 10).

Ruthven (1908) found pregnant females in July, August, and September in western Iowa. Females kept in captivity bore young August 31, September

7, 8, 29, and 30. He states, "I believe that broods may appear as early as the latter part of July."

Cieslak (1945) found the earliest parturition to be August 2, and the last pregnant females observed, August 23. Most of his females gave birth during the first week in August in the Chicago region.

Blanchard and Blanchard (1940) stated that the period of gestation in *T. sirtalis* was affected by temperature and estimated that a rise of 1° F. in average temperature brought the birth date 4.5 days earlier. In the vicinity of Ann Arbor, Michigan, Blanchard and Blanchard (1941) found that mating in *T. sirtalis* occurred from the middle of March to early May on days of suitable weather, and Cieslak found mating around the first of May for *T. radix* in the vicinity of Chicago. It has recently been definitely shown that fertilization does not occur until at least a month after mating (Blanchard and Blanchard, 1940).

TABLE II

	<i>T. radix</i>	<i>O. vernalis</i>
Metal	55.8	41.0
Tarpaper and roofing	13.8	12.5
Rocks	13.5	22.8
Tile, brick, pottery	4.2	2.3
Paper, cardboard	3.0	2.3
Transite	1.8	5.7
Shoes, bags, leather	0.6	2.3
Linoleum, oil cloth, cork	1.2	0
Wood	2.7	2.3
Glass	0.3	0
Slag, dirt	0.9	2.3
Open	2.1	6.8

The mean temperatures for June, July, and August were 3° F. below normal, which, using the Blanchards' empirical relationship, would delay parturition from the first of August to the middle of that month. The actual difference between that date and the one observed (Sept. 2) must have been due to the unseasonably cold May, which presumably delayed mating.

Blanchard (1933) stated that hatching of *Opheodrys* eggs occurred from August 5 to September 4. We found the first young on September 2, and increasing numbers thereafter. Again the late date must be considered the result of a cold April and May.

No pregnant females were found among the first-year snakes, a fact that indicates that breeding does not occur until at least the second year for both species. The fact that the majority of females collected after the end of May were one-year olds and that most of the two-year olds had disappeared substantiates the belief that the pregnant females seek out special hiding places for the purposes of gestation.

#### COVER

Cover preference was apparently determined mostly by availability for both *Thamnophis* and *Opheodrys*. The numbers (expressed as percentage of the total) found under the various cover types are listed in Table II for both species.

The metal consisted of large sheets, flattened cans, license plates, signboards, and miscellaneous small pieces. The tarpaper was localized but consisted of large rolls and odd pieces. Significantly, only one snake was found under glass, although there was much glass in the area; nor were the snakes associated with garbage dumps or rotting debris of any kind. There was a seasonal change in cover preference as indicated by the following percentages for *Thamnophis*.

	May	June	July	August	September	October
Metal	76.2	55.4	39.7	52.0	58.4	30.8
Rock	7.5	17.5	17.8	20.0	19.5	15.4
Tarpaper	6.2	5.2	20.5	24.0	5.6	30.8

During the hot months there was a tendency for the snakes to abandon the metal, which became unbearably hot during the day, for the cooler hiding places such as the rocks. The tarpaper was usually too thick and too well insulated to allow the sun's heat to reach the bottom sheets and hence afforded a cooler retreat than would otherwise be expected.

#### PREDATION AND MORTALITY

No direct predation on the snakes was seen, although rats (*Rattus*) and mice (*Mus* and *Peromyscus*) were found. In the spring a marsh hawk and several herons frequented the inundated fields for several weeks. In spite of the lack of visual evidence, 6.7 per cent of *Thamnophis* and 3.8 per cent of *Opheodrys* captured had various amounts of their tails missing. Additional specimens had scars over various regions of the body; one green snake had a severely injured eye. One newly born green snake had numerous scars over the back and on the belly and tail; its survival did not appear to be very probable, yet it was recovered four weeks later, still very much alive but with most of its tail gone. Near one of the victory gardens some of the brush had been burned off; 3 garter snakes and a green snake were found under a piece of metal, killed by the heat from the fire. No more snakes were found in this burned-over area until the vegetation had grown back.

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## The Post-cranial Skeleton of *Aprasia repens*

By PAUL SCOTT STOKELY

THE pygopodid lizard *Aprasia repens* Fry was at one time designated as *Ophioseps repens* (Kinghorn, 1926) and it is under the former name that Camp (1923) refers to the species when he points out that up to that time its shoulder girdle had not been investigated. Although I scanned the literature and the abstracts, I failed to find any description to date of the pectoral girdle. A renewed interest in problems of reptile morphology makes patent not only the need for an investigation of the shoulder girdle but also of the entire post-cranial skeleton of this form, which represents one of the extremes of specialization within the essentially limbless Pygopodidae.

The single specimen of the lizard upon which this report is chiefly based was made available by Mr. Arthur Loveridge from the collections at the Museum of Comparative Zoology in Cambridge, Massachusetts.<sup>1</sup> The specimen bears the number 33033 and was taken at Rottnest Id., Western Australia. A modification of the Schultze method was used for clearing the specimen and staining the bones and calcified cartilages with alizarin sulfonate of

<sup>1</sup> I wish to express my indebtedness to Dr. Rainer Zangerl, Curator of Fossil Reptiles, at the Chicago Natural History Museum, for his guidance as well as for his making available facilities for study and research. My thanks also go to Mr. Arthur Loveridge of the Museum of Comparative Zoology at Harvard University and to Mr. Karl P. Schmidt, Chief Curator of Zoology at the Chicago Natural History Museum, for the loan of valuable specimens upon which this report is based.



sodium (Davis and Gore, 1936). Both macroscopic and microscopic observations were made and the drawings were made with the aid of a camera-lucida; Figures 1 and 3 are about 7.8 times and Figure 2 is about 12 times the natural size.

#### THE VERTEBRAE AND RIBS

An approach to the description of the spinal column of species with such a snake-like habitus as that of *Aprasia repens* meets the difficulty of regional differentiation necessary for adequate description. Zangerl (1945), when confronted by such situation in the Amphisbaenidae, proposed a set of arbitrary criteria, which enabled him to separate the vertebral axis into four regions. By using somewhat different standards for *A. repens*, the writer distinguishes four vertebral regions as follows: cervical, anterior vertebrae (including atlas and axis) without ribs; thoraco-lumbar, vertebrae bearing freely movable ribs; cloacal, vertebrae in the vicinity of the pelvis with short transverse processes but without ribs or ventral processes; caudal,<sup>2</sup> vertebrae in the tail region with ventral processes but without detectable transverse processes. Using these criteria it is possible to distinguish in *A. repens* 3 cervical, 107 thoraco-lumbar, 2 cloacal, and 45 caudal vertebrae.

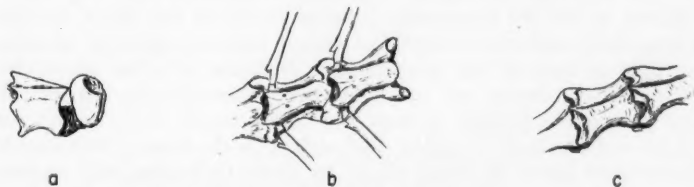


Fig. 1a. Lateral view of the atlas and axis.

Fig. 1b. Ventral aspect of the vertebral column in the thoraco-lumbar region. (Anterior is to the left.)

Fig. 1c. Dorso-lateral view of the vertebral column in the thoraco-lumbar region. (Posterior is to the left.)

The cervical vertebrae consist of the atlas, axis and one immediately posterior to the axis. The atlas is a simple structure of two laterally curved pieces of the neural arch that are dorsally united. The axis is noticeably larger than the other vertebrae. The odontoid process is large and is undercut at its anterior end. At its forward end, the termination is a ball-like tip behind which there is a slight constriction. From Hyman's reference (1942) concerning the work of Hayek, one might infer that this little knob represents the pro-atlas. However, this can hardly be the case since the pro-atlas ought to be in front of the atlas and dorsal to it (Evans, 1939). The neurapophyses of the axis join dorsally in a low crest that continues for-

<sup>2</sup> Because the post-anal and post-sacral regions of tetrapods are not always co-extensive, Mahendra (1943) thought the indiscriminate use of the term "tail" for the entire post-sacral region to be confusing. He proposed that the entire post-sacral region be designated as the coccygeal region and that the word "tail" or cauda be reserved for the post-anal part. There are several objections to the adoption of this proposal. In osteology (particularly if the material happens to be fossil) we know nothing of the position of the anus. Thus we must resort to the traditional concept "tail" for the part that comes after the sacrum (or cloacal region in the case of *A. repens*). Then, too, it is known that during the embryonic development of some teleost fishes, the position of the vent shifts as does the position of the anal fins and some other organs.



ward as a slight point and posteriorly as a somewhat shorter point (Fig. 1a). Both the axis and the third cervical vertebra have slight transverse processes. The third cervical vertebra resembles those of the thoraco-lumbar region except that it bears no ribs.

A marked uniformity throughout is characteristic of the vertebrae of the thoraco-lumbar region. The centra are slightly larger toward the middle of the region and become progressively smaller toward either end. Each centrum is a procoelous structure, is wider at its forward end, tends to constrict slightly toward its middle and then broadens again posteriorly (Fig. 1b). However, the convex posterior end is not as wide as the concave end. On most of the centra, but not on every one, a pair of prominent foramina could be seen. These are located ventrally on either side of the centrum in its anterior half. Such foramina and a lateral constriction of the centrum are mentioned by Camp (1923) as being among the gekkonid characters retained by the pygopodids. Similar conditions were observed by Zangerl (1945) in amphisbaenids. All of the vertebrae in this region are provided with well-developed pre- and post-zygapophyses. Stubby transverse processes project ventrad from each centrum and provide surfaces for rib articulation. The neurapophyses appear as low roof-shaped structures (Fig. 1c).

Except for the two in the most posterior portion of this region, the ribs are remarkably uniform in length and are but narrowly separated ventrally from their partners on the opposite side. Beginning at about the fourth anterior rib the proximal ends of the ribs have tuberosities directed cranial. These prominences increase in strength near the middle of the region and diminish and eventually disappear just anterior to the cloaca. Such muscle processes were figured by Camp (1923) for *Lialis*, *Ophisaurus*, and *Amphisbaena*. On the ribs of amphisbaenids Zangerl (1945) terms similar structures "tendon processes" and states that they are not tubercula. He further notes that they faced cranial only in *Rhineura* and caudad in the other genera of this family examined.

The vertebrae of the cloacal region have little to distinguish them from those of the thoraco-lumbar group. There are no ribs and the transverse processes are plainly visible. Forked transverse processes, which he called lymphapophyses, were found present in the cloacal region of many snakes, amphisbaenids, and snake-like lizards by Salle (1880). The presence of lymphapophyses in the Amphisbaenidae was affirmed by Zangerl (1945). I was able to find these lymphapophyses in *Anguis fragilis* and *Ophisaurus ventralis*, but there was no indication of them in *Aprasia repens* or in two other pygopodids, *Lialis jicari* and *Delma frazeri*.

The caudal vertebrae consist primarily of a conspicuous centrum. Vertebral apophyses are conspicuous only on the first four or five and from there on they tend to reduce and vanish altogether—only the neurapophyses persisting throughout. The last two caudal vertebrae are anomalous and have but a trace of haemapophyses present. Complete haemapophyseal processes<sup>3</sup>

<sup>3</sup> Haemapophyseal processes are normally articulated to the vertebral centra. As far as can be ascertained from the adult specimen examined, in *A. repens* there are ventral processes, at least functionally equivalent to haemapophyses, which may be true haemapophyses which have become reduced so that they no longer articulate with the centra. In the amphisbaenids, Zangerl (1945) found haemapophyseal processes which were fused to the centra of the caudal vertebrae.

are present for each of the other caudals. They arise between successive centra, but do not articulate with them. The pairs fuse distally. In all except the first few caudal vertebrae the centra are divided transversely by a suture just anterior to the middle. These fissures are wider and deeper than the natural breaking points found in the tail vertebrae of most lizards. The neural spines are double and are comparatively more conspicuous than on the vertebrae of the anterior regions. Fission of the centra was reported by Cope (1892) to exist in the caudal vertebrae of some genera of Iguanidae, Anolidae, Teiidae, Lacertidae and Scincidae. He found the double neural spines in *Dipsosaurus*, *Anolis*, and *Lacerta* to be present along with the split centra.

#### THE PECTORAL GIRDLE

The vestigial shoulder girdle lies ventral to the fourth, fifth and sixth vertebrae (Fig. 2). It consists of five pieces all practically of the same width lying contiguous one piece to the other in the form of the letter "U" with the arms directed antero-dorsad.

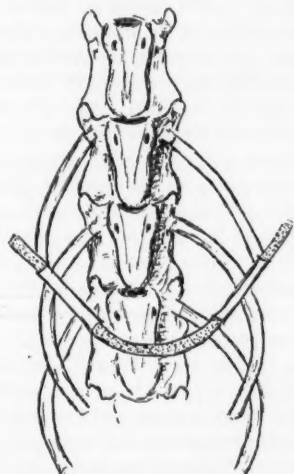


Fig. 2. The vestigial pectoral girdle as seen from below. The third cervical and the first three thoraco-lumbar vertebrae are shown.

The median and lowermost piece is of calcified cartilage. I interpret this as representing a vestige of the sternum. One might conceivably identify the element as a vestige of the clavicles. But until it be proved that the clavicles ever become unpaired, we must interpret this median cartilage as a sternal element.

There are considerations that would lead one to suppose that this structure might be a remnant of the clavicles. The writer has before him cleared specimens of two other species of Pygopodidae; viz., *Delma frazeri* and *Lialis jicari*. Each of these manifests marked conditions of degeneration—there being no signs of anterior limbs in either—and the pectoral girdle of each

lacks the interclavicle and anterior portion of the sternum. But both have well-developed clavicles. In *Lialis jicari* reduction has proceeded farther than in *Delma frazeri* as is evidenced by the greater elongation of the trunk and by the absence of both zeugopodium and autopodium in the vestigial hind limbs. Yet even in *L. jicari* the clavicles still remain well developed while the sternum persists only as a vestigial posterior part. Since the clavicle persists in these forms as a far better developed element than does the sternum, it would seem possible that the remnant forming the ventral, middle piece in *Aprasia repens* is likewise clavicle. Camp (1923) states that in the Anguimorpha the clavicle seems to persist after all other pectoral elements have vanished.

Some difficulty in identifying the part in question as a vestige of the clavicles is presented by the acceptance of the clavicles as dermal bones (Gegenbaur, 1865; Fürbringer, 1870; Kingsley, 1925; Williston, 1925; Hyman, 1942) which one does not ordinarily expect to find in a cartilaginous state. However, the vestigial pectoral girdle figured by Fürbringer (1870) for a skink, *Acontias niger*, is quite similar to that of *Aprasia repens* in this report. Fürbringer explains that in *Acontias niger* the clavicles do not exist as independent bones but that histological studies have proved that their vestiges are present, reinforcing the precoracoids medially.

Camp (1923) says that in the final stages of reduction both scapulo-precoracoid and clavicle become cartilaginous but retain characteristic muscle attachments. In a cleared specimen of *Ophiognomon abendrothi* in my hands, only half of the right side of the shoulder girdle is ossified—the entire scapula, suprascapula and the lateral half of the clavicle are formed of possibly hyaline cartilage; yet this does not appear to be in the final stage of reduction. If the clavicle is truly a membrane bone, then perhaps in it also the cartilage stage is a neomorph, as has been suggested by Watson (1918) to be the case with the human clavicle, analogous to the development of the mammalian lower jaw, pterygoid and other facial bones.

Contiguous with the middle piece laterally on each side is a bone—longer than wide and slightly expanded on both ends. This probably represents the remains of the fused scapula and precoracoid. The resemblance between the degenerate pectoral girdle and the early embryonic stages was discussed by Camp (1923). Since in the embryonic condition the scapula and precoracoid are formed from a single cartilaginous plate, one is led to interpret the bony elements of the pectoral girdle of *A. repens* as scapulo-precoracoid. On either side of the girdle, a short rectangular piece of calcified cartilage joins the dorso-anterior extremity of the scapulo-precoracoid; this I take to be the suprascapula.

#### THE PELVIC VESTIGES

The three elements of the posterior girdle are represented on each side (Fig. 3a) but only the ilium fails to be remarkably reduced. Indeed, the ilium appears to be rather specially developed (Fig. 3b). It is directed postero-dorsad and is broadened into a peculiar leaf-like structure with an apical point. Short projections from the region of the acetabulum toward the midline probably represent the pubes anteriorly and the ischia posteriorly. The ventral processes of the girdle are widely separated medially

and probably function as supporting structures for the cloacal region. The vestigial femur, directed postero-ventrad, may be seen in Figs. 3a and 3b. The femur lacks a trochanter and is almost the same width throughout its length, which is greater than the length of either the ischiac or pubic stubs. A tiny bit of calcified cartilage can be seen at the distal tip of the femur, the only possible indication of a zeugopodium. On the whole the pelvis is quite comparable to that of *Pygopus lepidopus* as figured by Fürbringer (1870).



Fig. 3a. The pelvic vestiges in ventral view. The last two thoraco-lumbar and the first cloacal vertebrae are shown.

Fig. 3b. The lateral aspect of the left pelvic vestige.

#### MORPHOLOGICAL CONCLUSIONS

It was pointed out by Camp (1923) that *Aprasia repens* represents the most extreme burrowing habitus developed among the Pygopodidae. The specimen examined for this report was nearly 18 centimeters in length and less than one-half centimeter in diameter at its thickest point and the distance between the two girdles accounted for approximately 60 per cent of the total length. The striking resemblances in general habitus found among the extreme burrowing forms in rather widely separated groups has been noted by Zangerl (1945) in his work on the Amphisbaenidae. He calls attention to resemblances common to the lizards *Ophiognomon abendrothi*, *Aprasia repens* and some Amphisbaenidae and to the burrowing snake, *Leptotyphlops d. dulcis*. It has already been mentioned above in this paper that notable similarities exist between the vestigial pectoral girdles of *Acontias niger* (Scincomorpha) and *Aprasia repens* (Anguimorpha) and that the pelves of *Pygopus lepidopus* and *Aprasia repens* are quite similar. Correlated with the subterranean habits of these reptiles is a high degree of convergence in habitus and yet there are many non-conforming and irregularly appearing differences. The forked transverse processes of the cloacal vertebrae are common to many snakes (Salle, 1880), to the amphisbaenids (Salle, 1880, and Zangerl, 1945) as well as to the limbless lizard, *Anniella pulchra* (Coe and Kunkel, 1906), but are missing in *Aprasia repens*. However, the transverse split in the centra of the caudal vertebrae of *A. repens* is likewise found in *Anniella pulchra*. Caudal chevrons are generally considered to be characteristically lacking among burrowing forms (Camp, 1923) but Coe and Kunkel (1906) say they are present in *Anniella pulchra*. And at least a functional equivalent to true chevrons was found by the writer in *Aprasia repens* and by Zangerl (1945) in amphisbaenids.

The writer<sup>4</sup> can confirm Camp's (1923) view that the parasternalia are more highly developed among the Scincidae as specializations toward a burrowing habitus increase. Yet apparently equally specialized burrowers among the Pygopodidae show only probable traces of any parasternalia. All of which seems to indicate more clearly that the changes toward a worm-like or a snake-like habitus have had several quite independent points of departure. The end results have much in common but always with indications of their phylogenetically separate origins.

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<sup>4</sup> Work in progress.

## Comparative Behavior of Various Fishes Under Differing Conditions of Aggregation

By C. M. BREDER, JR. and JANET ROEMHILD

### INTRODUCTION

THE method of estimating the aggregating tendencies of fishes, which utilizes an analysis of the frequency of their occurrences in certain areas as compared with the expectancy based on binomial distribution, has been found useful in studies concerning differential behavior. Mexican blind and eyed characins have been so studied by Breder and Gresser (1941a, 1941b), Breder and Rasquin (1943) and Breder (1944). The phenotypic color variations displayed by goldfish have been studied by Breder and Halpern (1946).

The present communication is concerned with exploratory considerations involving other species and influences not studied in the earlier work. There has been no intent to examine any one of these extensively at this time, but rather to sketch the general expectations to be found in this kind of a preliminary survey with a view to obtaining a better understanding of the methods and its range of usefulness as well as its limitations.

The laboratory work was carried on in the quarters of the Department of Animal Behavior through the courtesy of Dr. Frank Beach and experiments numbers 2 and 3 were performed by Mr. B. Nathanson, to whom thanks is due.

### EXPERIMENTAL WORK

The equipment used was the same as that employed in the earlier work. A trough measuring 39 by 24 inches and carrying water to the depth of 2 inches was optically divided by a dark thread above, but close to, the surface of the water so that there were in effect two equal areas, each  $19\frac{1}{2}$  by 24 inches, in which the fish were free to move. Here the numbers of fishes in one of these areas were counted every 5 seconds for 100 times and then removed. They were allowed to accommodate themselves to the trough for at least 10 minutes before the counts were started, as it was found by experience that in such an interval of time, for most species, all evident fright from handling had passed. Opposite ends of the trough were used for alternate experiments to overcome any possible inherent bias due to obscure influences and are indicated as "A" and "B" in Table I. It had been clear from the earlier work that if any such bias is present it is very slight.

Four fishes were used at a time, in most experiments, as it was found to be a convenient number from a purely practical standpoint. However, this figure was varied as seemed appropriate to the material at hand. The results of these readings are given in Table I together with pertinent data. Each of the experiments is made up of five to ten of the procedures described above and then combined to give the figures of the table. It has

been clearly indicated in the earlier work that counts of from 500 upwards indicate the main trends in an unequivocal manner.

It is unnecessary here to describe in detail the individual items of behavior of the four additional species to which this method has been applied as this is brought out adequately in the discussion, which compares the current studies with those previously reported.

TABLE I  
BINOMIAL DISTRIBUTION OF VARIOUS SPECIES OF FISHES

Exp. no.	No. of fish at one end of trough	Observed distribution of four fish <sup>1</sup> "A" end, "B" end, total in %	No. of observations and remarks
<i>Brachydanio rerio</i>			
1	0	166	149 31.5
	1	72	50 12.2
	2	51	39 9.0
	3	63	36 9.9
	4	148	226 37.4
<i>Ameiurus nebulosus</i>			
2	0	16	— 3.2
	1	133	— 26.6
	2	178	— 35.6
	3	134	— 26.8
	4	39	— 7.8
3	0	0	— 0.0
	1	1	— 0.2
	2	31	— 6.2
	3	62	— 12.4
	4	116	— 23.2
	5	131	— 26.2
	6	66	— 13.2
	7	51	— 10.2
	8	35	— 7.0
	9	7	— 1.4
	10	0	— 0.0
	11	0	— 0.0
	12	0	— 0.0
4	0	74	81 15.5
	1	98	117 21.5
	2	125	120 24.5
	3	117	95 21.2
	4	86	87 17.3

<sup>1</sup> Exp. 3 used 12 fish.

#### DISCUSSION

The method of obtaining an estimate, in terms of binomial distribution, of the behavior of fishes as reflected in their locomotor activity, was established primarily as a measure of reactions to gradients. These included light and darkness, Breder and Gresser (1941a, 1941b) and Breder (1944), and chemical quantities, Breder and Rasquin (1943). In connection with these interests it appeared that this method could also be applied nicely



in estimating reactions of fishes to companions. It was used extensively for this differentiation by Breder and Halpern (1946). Obviously then, any influence in a fish's environment to which it reacts by differential locomotor activity, whatever the sensory system intermediating the activity, should be measurable by this means. Thus, what were "control periods"

TABLE I (continued)  
BINOMIAL DISTRIBUTION OF VARIOUS SPECIES OF FISHES

No. of fish Exp. at one end no. of trough	Observed distribution of four fish "A" end, "B" end, total in %			No. of observations and remarks	
<i>Corydoras paleatus</i>					
5	0	177	103	28.0	1,000 Fish kept in a large aquarium with goldfish.
	1	58	66	12.4	
	2	53	98	15.1	
	3	17	84	10.1	
	4	195	149	34.4	
6	0	195	204	39.9	1,000 Fish kept in a small aquarium by themselves.
	1	18	24	4.2	
	2	54	30	8.4	
	3	13	22	3.5	
	4	220	220	44.0	
<i>Lebistes reticulatus</i>					
7	0	125	187	31.2	1,000 Males only. From a mixed tank.
	1	59	39	9.8	
	2	72	27	9.9	
	3	73	43	11.6	
	4	171	204	37.5	
8	0	272	237	50.9	1,000 Females only. From a mixed tank.
	1	21	6	2.7	
	2	8	1	0.9	
	3	31	15	4.6	
	4	168	241	40.9	
9	0	147	94	24.1	1,000 Two males and two fe- males. From a mixed tank.
	1	44	77	12.1	
	2	79	80	15.9	
	3	49	133	18.2	
	4	181	116	29.7	
10	0	101	—	20.2	500 Two males and two fe- males which had been kept separate as to sexes.
	1	37	—	7.4	
	2	164	—	32.8	
	3	62	—	12.4	
	4	136	—	27.2	

in the earlier experiments showed themselves as measures of the influence of the only detectable differential present in the field of the specimens, namely, their companions, both quantitatively and qualitatively. Consequently one need only provide a shallow container with no horizontal gradients, so that a uniform field is presented, to obtain such measures of the influence of individuals on each other. By varying the conditions and numbers it should then be possible to study the comparative strength and direction of one factor of influence as compared with another. At least the following list of factors should be amenable to treatment in this fashion.

1. Vision and its lack
  - a. Color
  - b. Hue
  - c. Brightness
2. Hearing and lateral-line sense
3. Smell and taste
  - a. Olfaction
  - b. Taste
  - c. Common chemical sense
4. Effect of heterotypic grouping
  - a. Varying phenotypes
  - b. Mixed species
  - c. Sexual differences
  - d. Ontogenetic stages
5. Effect of numbers in group
6. Effects of isolation and past history

Undoubtedly this list could be considerably extended and is probably limited by the imagination of the individual investigator more than by any inherent limitation in the method. A considerable start has already been made on several of the items in the above list. The earlier work elucidated, to some extent at least, a part of items 1, 3, 4 and 6. The hitherto unreported experiments of Table I concern chiefly items 4, 5 and 6, the details of which follow, according to the species employed.

*Brachydanio rerio* (Hamilton-Buchanan)

Experiment 1 shows that this species behaves in a manner very similar to that of *Carassius* when phenotypes of one color alone are present. The concave curve is similar to those of that type listed in Table II. In Figure 1, compare 1, which represents *Brachydanio*, with 16 and 18 which represent uniformly colored goldfish. This evidently is typical of such loosely compacted groups, and is probably the behavior shown by most members of the family Cyprinidae. Under certain conditions similar groups are formed by *Corydoras*, 5 and 6, and *Lebistes*, 7, 8, and 9. (See the discussion under both of these heads.) That this is not the invariable form of a homogeneous group of visually actuated fishes is indicated by 11. However, curve 11 may be considered as the extreme of this form of figure, where all four fishes are always at one end of the trough or the other. As noted by Breder and Gresser (1941a), eyed *Astyanax* could not be measured directly in this manner. Because of this difference curve 11 must be considered theoretical, since actual readings were not made. However, there can be no question that they would take this form. In such a trough, with nothing to hide behind, *Astyanax* huddle together in one corner and stay there until some influence causes them to rush in a group to another corner. Aside from the fact that these fish are very "nervous" and nearly as prone to jump out as to rush to another corner, it would be simply a matter of making enough readings to obtain such a distribution. This is sufficiently evident upon observation to make the undertaking unwarranted. It is a case of complete optical fixation in an otherwise "blank" environment. In an aquarium containing plants, stones, and other items the behavior is different because the fish are then not nearly so tied to one another. The effects of blindness reverse the curvature of this type of figure, and the form approaches that of binomial distribution, as is indicated in curves 12, 13, 14, 15, and 17 which cover blind *Astyanax*, *Carassius*, and two types of normally blind cave fish. The modifications of behavior obtained by mixing blind and seeing *Carassius* are indicated in 21 and 22, while groups of fishes of different colors deform the figures in 19 and 20, both of which items are discussed in detail by Breder and Halpern (1946).

*Ameiurus nebulosus* (Le Sueur)

Since *Ameiurus* lives in a tightly compacted juvenile aggregation which is guarded and herded about by the parents for some time, and since this

TABLE II

COMPARISON OF AGGREGATIONS OF SPECIES AND CONDITIONS INCLUDING DATA OF OTHERS

Exp. no.	Species, condition, and number of observations	Aggregations in per cent					
		0	1	2	3	4	5
<i>Astyanax mexicanus</i>							
11	Normal (see text)	50	0	0	0	50	
12	Blind (3200) <sup>1</sup>	6	25	37	25	7	
<i>Anoptichthys jordani</i>							
13	Normal (6184) <sup>1</sup>	7	23	36	26	8	
14	Anosmic (1400) <sup>1</sup>	8	27	40	20	5	
<i>Anoptichthys</i> sp.							
15	Normal (3200) <sup>1</sup>	10	26	33	24	7	
<i>Carassius auratus</i>							
16	Normal (200) <sup>1</sup>	27	13	12	7	14	27
17	Blind (1000) <sup>2</sup>	9	28	37	20	5	
18	One color (4000) <sup>2</sup>	37	12	9	11	30	
19	Two of each (2000) <sup>2</sup>	39	10	6	9	36	
20	One odd (4000) <sup>2</sup>	21	20	16	32	11	
21	Two blind (4000) <sup>2</sup>	13	24	21	27	19	
22	One blind (2000) <sup>2</sup>	15	19	19	26	20	
<i>Brachydanio rerio</i>							
1	Normal (1000)	32	12	9	10	37	
<i>Ameiurus nebulosus</i>							
2	Brood (500) <sup>3</sup>	3	26	36	27	8	
4	Past brood (1000)	16	21	25	21	17	
<i>Corydoras paleatus</i>							
5	Goldfish (1000)	28	12	15	10	35	
6	Alone (1000)	40	4	8	4	44	
<i>Lebistes reticulatus</i>							
7	Males (1000)	31	10	10	12	37	
8	Females (1000)	51	3	1	4	41	
9	Both (1000)	24	12	16	18	30	
10	Isolates (500)	20	8	33	12	27	
Theoretical expressions							
(1)	Binomial distribution	6.25	25.00	37.50	25.00	6.25	
(2)	Reciprocal of (1)	37.50	9.375	6.25	9.375	37.50	
(3)	Mean of (1) and (2)	21.875	17.1875	21.875	17.1875	21.875	
(4)	Reciprocal of (3)	18.125	22.8125	18.125	22.8125	18.125	
(5)	Mean of (3) and (4)	20.00	20.00	20.00	20.00	20.00	
(6)	Reciprocal of (5)	20.00	20.00	20.00	20.00	20.00	
(7)	"N" shaped figure	x-y	x+y	x	x-y	x+y	
(8)	Inverse of (7)	x+y	x-y	x	x+y	x-y	
(9)	Absolute segregation	50.00	0.00	0.00	0.00	50.00	
(10)	Absolute dispersion	0.00	0.00	100.00	0.00	0.00	

<sup>1</sup> From Breder and Rasquin (1943).<sup>2</sup> From Breder and Halpern (1946).<sup>3</sup> See Table I for data on 12 young *Ameiurus*, experiment 3.

school subsequently breaks up with the young fishes going their separate ways to lead more or less solitary lives except for breeding, hibernating, or other temporary causes of group formation, it seemed that a reflection of this behavior might be measured by testing fishes in various stages. Young taken from the brood aggregation and others taken after it had broken up were so tested. The results are shown in 2 and 4. Here it is evident that

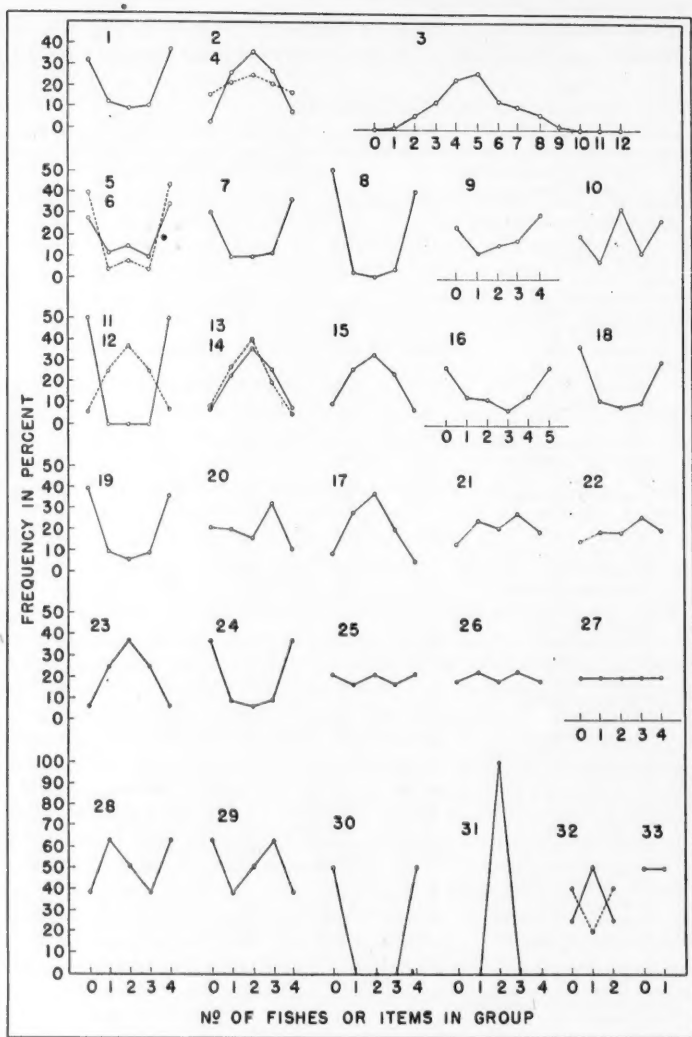


Fig. 1. Observed frequency distribution of various species of fishes under different conditions of aggregation. Horizontal indices; number of fishes observed. Vertical indices; frequency of occurrence in per cent.

1. *Brachydanio rerio* adults.
- 2 and 3. *Ameiurus nebulosus* young taken from juvenile brood.
4. *Ameiurus nebulosus*, larger past brood stage. (dotted line)
5. *Corydoras paleatus* adults, kept with *Carassius*.
6. *Corydoras paleatus* adults, kept alone. (dotted line)

such young removed from the brood do not follow one another but approach closely to random distribution, in fact, slightly more so than do those that had voluntarily left the school at a greater age. It was thought that perhaps a somewhat larger number was necessary to make this juvenile aggregating tendency effective. Consequently, 12 fish were tested, which in itself was somewhat of an observational feat. The result is consistent with that of the group of 4, and is shown as 3 in Figure 1. While these experiments were in progress others from the same brood were living in a small artificial lily pond without their parents. For a long time after these experiments had been finished these fish were still in a group. However, in the absence of their parents and without their herding efforts, small groups would stray from the main body and not infrequently as few as 6 would be in a small but otherwise typical aggregation in this pool. Thus it is evident that 12 was an adequate number to form an aggregation if the fish had been so disposed. At this time it is not clear just what influence is at work to cause this evident reversal of behavior upon transfer to an aquarium. A full study of this by means of serial stages should be illuminating.

#### *Corydoras paleatus* (Jenyns)

The distribution of this species shows some interesting and suggestive features. One group, shown as curve 5, was kept in a large aquarium with

Fig. 1 (continued)

7. *Lebistes reticulatus* males.
8. *Lebistes reticulatus* females.
9. *Lebistes reticulatus*, two males and two females.
10. *Lebistes reticulatus*, two males and two females after isolation.
11. *Astyanax mexicanus*, normal theoretical curve.
12. *Astyanax mexicanus*, blind.<sup>1</sup> (dotted line)
13. *Anoptichthys jordani*, normal.<sup>1</sup>
14. *Anoptichthys jordani*, anosmic.<sup>1</sup> (dotted line)
15. *Anoptichthys* sp., normal.<sup>1</sup>
16. *Carassius auratus*, normal one color.<sup>1</sup>
17. *Carassius auratus*, blind.<sup>2</sup>
18. *Carassius auratus*, normal one color.<sup>2</sup>
19. *Carassius auratus*, two yellow and two gray.<sup>2</sup>
20. *Carassius auratus*, one fish of different color.<sup>2</sup>
21. *Carassius auratus*, two fish blind.<sup>2</sup>
22. *Carassius auratus*, one fish blind.<sup>2</sup>

#### Theoretical frequencies.

23. Binomial distribution. Expression (1).
24. Reciprocal of binomial distribution. Expression (2).
25. Mean of expressions (1) and (2). Expression (3).
26. Reciprocal of expression (3). Expression (4).
27. Mean of expressions (3) and (4). Expressions (5) and (6).
28. "N"-shaped figure. Expression (7).
29. Inverse of "N"-shaped figure. Expression (8).
30. Absolute segregation. Expression (9).
31. Absolute dispersion. Expression (10).
32.  $n = 2$ . Expression (1) and (2).
33.  $n = 1$ . Expression (1).

<sup>1</sup> From Breder and Rasquin (1943).

<sup>2</sup> From Breder and Halpern (1946).

goldfish and another, shown as curve 6, in a small one by itself, prior to the tests. If the differences of these two similar figures can be taken as significant, it would suggest that they become a closer knit group by virtue of dwelling in a small confine undisturbed by numerous other fishes. In this experiment the large aquarium measured  $3\frac{1}{2} \times 2 \times 1\frac{1}{2}$  feet and contained about 100 goldfish and the small aquarium measured  $10 \times 8 \times 6$  inches. It will be noted that these two figures each have a raised value at their center. This, slight as it is, apparently has a significance which appears much more clearly in another part of this study and is discussed under *Lebistes*. Although *Corydoras* belongs to a group that often shows solitary habits as adults, it is clear that these fishes have a strong aggregating tendency, and a parallel study of these along with that suggested for *Ameiurus* should be worth while. This species alone, of those here considered, required more than 10 minutes to quiet down from the handling necessary to introduce them to the trough.

#### *Lebistes reticulatus* (Peters)

In this sexually dimorphic species it was found that the sexes when tested separately showed typical concave figures, as indicated in 7 and 8, the female groups evidently being somewhat more closely knit, in fact approaching the theoretical figure shown in 11 for a completely tied group. When 2 of each sex were tested together the figure became flatter than either males or females alone, as is shown in 9, although it is still of the concave form of an aggregating type of fish, the flattening being evidently due to the persistent sexual activity of the males of this species. In this connection it should be noted that the 2 males tended to stay together, and the 2 females likewise, and not, as might be supposed, 2 pairs of opposite sex. The females alone (8) tended to hug the sides and the males alone (7) tended to stay in the center of the trough, evidently the combination producing the flattening of (9). These fish had been living together in a small aquarium. When 2 of each sex that had been sexually isolated for 20 days were tested, a very different figure resulted. This condition is shown in 10. Here, with the heightened sex activity, a saw-tooth "W" type of figure appears. This appears to be the reciprocal of the figures found by Breder and Halpern (1946) to occur on a non-sexual basis in *Carassius* when two blind and two seeing fish were tested together. Their figures are shown in 21. Thus, evidently equally divided dimorphism (in both cases two of each) concerning various factors, produces saw-tooth figures. Where the two types are not equally numbered the modification of the resulting figure is as shown in 20 and 22. In regard to *Lebistes*, clearly the production of this type of figure, resting on sex starvation, disappears when adequate sexual expression is possible. Then the group aggregating tendency takes over to produce the concave figure shown in 10, as contrasted to 7 and 8. In this connection the little central peaks of the two *Corydoras* figures may represent sexual attention or at least a tendency to pair off.

#### TYPES OF FIGURES

*Binomial distribution*.—Fish without sight approach to theoretical

expectation for random distribution, as pointed out in detail by Breder and Rasquin (1943), fitting well with the expression  $(p + q)^n$ . This may also be seen under certain other conditions, as when a school of young *Ameiurus* or older solitary individuals are used. Thus, this form of figure may be an expression of blindness, disruption of aggregating tendencies, or a solitary attitude.

*Reciprocal distribution.*—It has been shown by Breder and Halpern (1946) that the concave figures produced by phenotypically similar goldfish appear to approach closely to the reciprocal values of binomial distribution, which has the expression  $(p + q)^{-n}$ . Others here reported hover about this value but it is clear that special influences may change it radically. This is in accordance with what should be expected, for, generally speaking, a fish with functional eyes is influenced by more factors in its environment than one in which this function is lacking. With complete optical tying, as in 11, there are only zero values for the intermediate distributions. Thus, the variation of figures between these two extremes gives a measure of the extent and strength of the aggregating tendency.

*Mean distributions.*—If a mean of the expressions  $(p + q)^n$  and  $(p + q)^{-n}$  be taken, it is found to produce a "saw tooth" curve which is similar to those obtained in sexually mixed groups of fishes under strong sexual stimulation. On the other hand, mixed blind and seeing, with no sexual activity, produce figures which approach the reciprocal of the above. Presumably similar figures would result from other differences in size, species, and age, among others, each of which represents problems still to be studied.

The expressions derived from the basic one for binomial distribution are all modifications based on reciprocal relationships and means. The full series are thus as follows:

- (1) Binomial distribution  
 $(p + q)^n$
- (2) Reciprocal of (1)  
 $(p + q)^{-n}$
- (3) Mean of (1) and (2)  
$$\frac{(p + q)^n + (p + q)^{-n}}{2}$$
- (4) Reciprocal of (3)  
$$\frac{2}{(p + q)^n + (p + q)^{-n}}$$
- (5) Mean of (3) and (4)  
$$\frac{(p + q)^{2n} + (p + q)^{-2n} + 6}{4(p + q)^n + (p + q)^{-n}}$$
- (6) Reciprocal of (5)  
$$\frac{4(p + q)^n + (p + q)^{-n}}{(p + q)^{2n} + (p + q)^{-2n} + 6}$$



These are all illustrated in Figure 1 with the following values assigned:  $n = 4$ ,  $p = \frac{1}{2}$ ,  $q = \frac{1}{2}$ . They are thus comparable to the experimental results since in the latter  $n$  = the number of fishes and  $p$  and  $q$  the two equal areas of the trough. The solution of the expansions of these expressions in terms of percentage is given in Table II.

The first four of these expressions have been approximated by fishes in the experimental troughs under various conditions, as already discussed. The last two have not been approached experimentally and these two both produce a horizontal line graphically, for all five numerical values are equal. Since (5) is the mean of (3) and (4) and these both seem to have been approximated, experiments should be undertaken combining these types. That is to say, an experiment should be developed combining an element of sex starvation and the presence of blind individuals. Since (6), which is the reciprocal of (5), shows identical values, nothing further could be expected in this direction.

A more puzzling condition, which has actually been found approximated in experiments, is that of the presence of a high value for "0" and "3" which appeared in the work of Breder and Halpern (1946) producing figures that somewhat resembled an "N" or an inverted "N". Because of the inherent symmetry in the preceding equations no such transformations as given could lead to this asymmetrical condition. If, however, some value,  $x$ , be assigned to "2," the middle element, then if  $x + y$ , on "1" and  $x - y$ , on "3" be equally greater and less, respectively, than  $x$ , the three values lie on a straight line irrespective of the magnitude of the values. If the value,  $x - y$ , and the value,  $x + y$ , on "0" and "4" respectively be established, then an "N" shaped figure is produced. The justification for such a procedure is found in considering (5) or (6) of Table II as a flattened "N" and its inverse, respectively. Then the following relations appear:

0	$x - y$		$x + y$
1	$x + y$		$x - y$
2	$x$	or	$y$
3	$x - y$		$x + y$
4	$x + y$		$x - y$

in which  $x$  and  $y$  may be any value indicated in Table II by (7) and (8).

The expressions (9) and (10) of Table II, and 30 and 31 of Figure 1 represent complete segregation and dispersion, respectively. The first, as has already been indicated, obtains in eyed *Astyanax* and the latter has not appeared. These two situations are of course more properly considered, not as the number of individuals =  $n$ , but as unit groups =  $n$ . Thus, if there are two groups of two they should be considered as  $n = 2$ , and if one group as  $n = 1$ , as indicated in 32 and 33 of Figure 1.

*Measures of significance.*—Thus far in this work no attempt has been made to examine the possible statistical significance of the finer differences between these curves, since only those large differences to which no question could be attached have been discussed. It so happens that in the more extensive work the changes in the form of the figures have been so gross as to make such refinement of handling unwarranted and it seems likely that this might, indeed, be one of the merits of the method where applicable.

If, however, any one set of data is compared with the binomial expression, which it resembles by the  $\chi^2$  test, it is found in each case, except three, the  $P$  values are less than 0.01. In other words, it is possible to attach some statistical significance to the divergencies from the theoretical ratios. It is not the purpose of this paper to go into these matters, as it would be difficult to associate them with any known item in the experiments in the absence of other corollary data. Such would have to be provided for at the time the experiments were performed. It is sufficient to point out now, that not only can the gross transformations of these ratios be used for analysis, but also clearly significant differences can be made out between visually similar curves by comparison of the expected and observed values. Furthermore, the number of observations actually made in connection with these studies, are, mainly, larger than required for such statistical analysis. Observations in the order of 500 should be adequate for most purposes:

The three cases which showed  $P$  values greater than 0.01 are as follows:

EXPERIMENT	NUMBER OF OBSERVATIONS	$P$ VALUE
2	500	0.02 +
12	3200	0.70
Exp. 10 of Breder and Rasquin (1943)	3200	0.02 -

Of these all but one are less than the generally accepted limiting value of 0.05, leaving only experiment 12, the blinded *Asytanax*, as showing no significant divergence from binomial distribution. It is to be noted both kinds of cave fish showed  $P$  values  $< 0.01$ , including one experiment on anomic fish.

This all indicates that although the figures approach those of the theoretical values given, and undoubtedly the influences indicated by them are a large factor in the behavior of the fishes, other more or less obscure factors prevent, in most cases, the theoretical values being approached to a point where they show no significant statistical difference. In a less rigorous way this has already been foreshadowed in the analysis of consecutive runs given by Breder and Rasquin (1943) and Breder and Halpern (1946).

#### SUMMARY

1. The method of analyzing the social attitudes of fishes by means of referring their distribution to the binomial  $(p + q)^n$  is discussed and extended.

2. Varying groups of fishes are found to approach three modifications of the expression,  $(p + q)^n$ . These are its reciprocal,  $(p + q)^{-n}$ , and the mean of the two expressions and its reciprocal.

3. The first, simple binomial distribution, is approached by normally blind cave fish, blinded specimens of normally eyed forms, specimens of disrupted aggregations, and solitary forms.

4. The second, the reciprocal of binomial distribution, is approached by homotypic groups of aggregating fishes with vision and may in some cases extend to 50-50 values at either extreme with no intermediate values, expressing complete optical binding.

5. The third, the mean of binomial distribution and its reciprocal, is approached with groups of fishes mixed as to sex.

6. The fourth, the reciprocal of the third, is approached by groups which may vary as to color, visual ability and probably to many others such as size, age, species, and past conditioning.

7. A method of estimating the statistical significance of differences between the measures so obtained is given.

8. Specific fishes studied include *Brachydanio rerio*, *Ameiurus nebulosus*, *Corydoras paleatus*, *Lebistes reticulatus*, the behavior of which under various conditions is compared with earlier work on *Astyanax mexicanus*, *Anoptichthys jordani*, and *Carassius auratus*.

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## Time of Appearance of Pink Salmon Runs in Southeastern Alaska

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THE Pacific salmon are available to the fishery only during their migration from the open ocean, through the straits and channels, to the streams where they spawn. In regulating this fishery, it is imperative to know the time of this migration so as to adjust the season to allow the fishermen to catch all fish not required for adequate seeding of the spawning grounds. With the passage of the White Law in 1924, closing dates for the fishery were established. In 1928, the regulations were extended to include

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an opening date as well as a closing date for fishing. As the opening date for pink salmon fishery has never been set late enough to provide protection for the early part of the runs, and the early closure of the season has provided protection for the latter part of the salmon runs, the early part of the

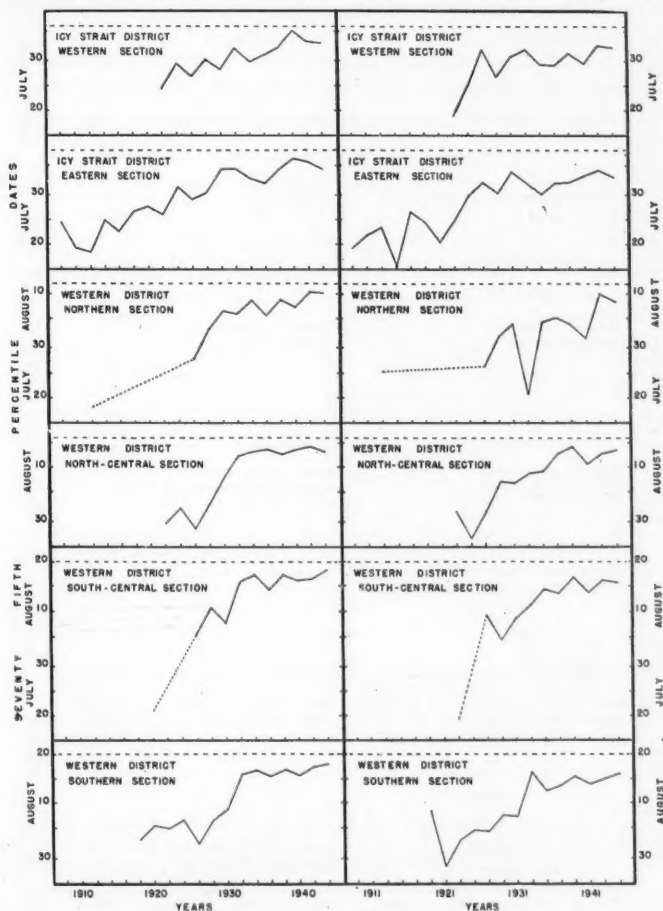


Fig. 1. Dates by which 75 per cent of the pink salmon trap catches have been made, even and odd year cycles, Icy Strait and Western districts of southeastern Alaska. (Truncation date shown by broken horizontal line.)

runs has been subjected to the full brunt of the fishery. The question has arisen whether or not the fishery is building up races of pink salmon that migrate late in the season at the expense of those that migrate early. It is the purpose of this paper to describe the changes in time of runs that have been observed.

Pink salmon (*Oncorhynchus gorbuscha*) can be divided into two distinct populations, the even-year population and the odd-year population. The eggs of the pink salmon are spawned in the gravel beds of the streams in the fall of the year and hatch the following spring. The fry emerge from the

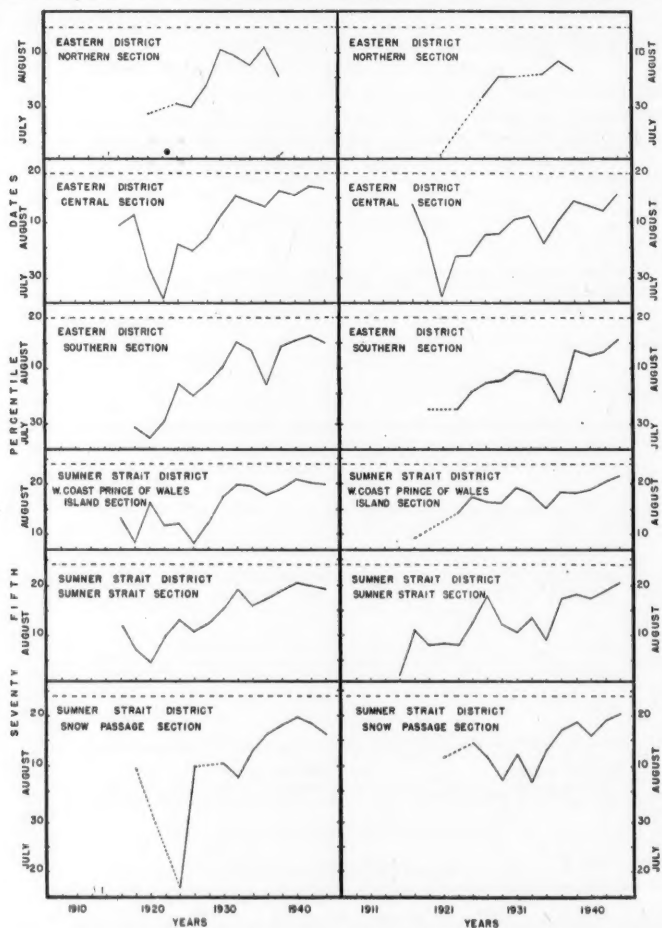


Fig. 2. Dates by which 75 per cent of the pink salmon trap catches have been made, even and odd year cycles, Eastern and Sumner Strait districts of southeastern Alaska. (Truncation date shown by broken horizontal line.)

gravel and migrate directly to the ocean where they feed until the summer of their second year. After attaining maturity in the ocean they return to the streams to spawn and die. The adults begin to migrate into the streams in July and continue to do so through August and part of September. This two-year life cycle has been found to be consistent. Thus the population

entering the catch on the even years is distinct from the population on the odd years. Therefore the analysis has been divided into two parts, the even-year population and the odd-year population.

Southeastern Alaska has four chief portals of entry for the salmon migrating from the ocean to the streams, namely (1) Cross Sound, (2) Christian Sound, (3) Iphigenia Bay, and (4) Dixon Entrance. From these entries the runs spread out through the straits and channels where traps are placed along the shores to intercept the runs. Since a trap is a fixed unit of gear

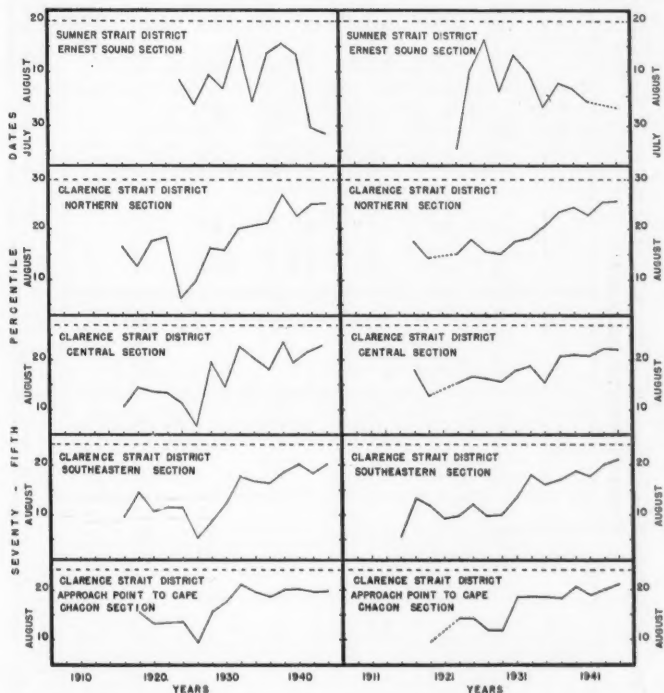


Fig. 3. Dates by which 75 per cent of the pink salmon trap catches have been made, even and odd year cycles, Sumner Strait and Clarence Strait districts of southeastern Alaska. (Truncation date shown by broken horizontal line.)

it samples the salmon migration passing that particular location. Daily catch records of the traps operated in Alaska, as far as they are available, have been collected. The date in the season by which 75 per cent of the pink salmon trap catch in the area was made has been used as an index of the time of the run in the area. This index was determined by computing first the average daily catch of the traps in the area and then computing the date by which 75 per cent of the seasonal average catch had been made.

As the migrations occur at different times during July, August and September in various parts of southeastern Alaska, the region has been

TABLE I  
DATES UPON WHICH SEVENTY-FIVE PER CENT OF THE PINK SALMON TRAP CATCH HAD BEEN MADE UP TO AND INCLUDING THE TRUNCATION DATE, BY  
DISTRICTS, SOUTHEASTERN ALASKA.

District and Section	Truncation Date	1908	1910	1912	1914	1916	1918	1920	1922	1924
Icy Strait District	Aug. 5									
Western Section	Aug. 7	July 24.5	July 19.1	July 18.3	July 24.9	July 22.6	July 26.4	July 27.6	July 24.2	July 29.4
Eastern Section									July 26.0	July 31.3
Western District										
Northern Section	Aug. 11			July 18.1					July 29.7	Aug. 1.7
North-Central Section	Aug. 15							July 20.8		
South-Central Section	Aug. 19							Aug. 3.4	Aug. 4.9	Aug. 6.8
Southern Section	Aug. 19						Aug. 2.6			
Eastern District										
Northern Section	Aug. 14							July 28.7	July 25.9	July 30.9
Central Section	Aug. 19					Aug. 9.5	Aug. 11.6	Aug. 11.1	July 30.6	Aug. 5.6
Southern Section	Aug. 19						July 29.5	July 27.4		Aug. 7.0
Summer Strait District										
W. Coast Prince of Wales										
Island Section	Aug. 23					Aug. 13.2	Aug. 8.5	Aug. 16.3	Aug. 11.9	Aug. 12.1
Summer Strait Section	Aug. 23					Aug. 12.4	Aug. 7.2	Aug. 4.7	Aug. 9.9	Aug. 13.1
Snow Passage Section	Aug. 23						Aug. 9.6			July 16.9
Ernest Sound Section	Aug. 19									Aug. 8.3
Clarence Strait District										
Northern Section	Aug. 29					Aug. 16.3	Aug. 12.8	Aug. 17.7	Aug. 18.4	Aug. 6.3
Central Section	Aug. 26					Aug. 10.6	Aug. 14.6	Aug. 13.7	Aug. 13.4	Aug. 11.3
Southeastern Section	Aug. 23					Aug. 9.7	Aug. 14.5	Aug. 10.6	Aug. 11.5	Aug. 11.4
Approach Pt. to Cape										
Chacon Section	Aug. 23						Aug. 15.5	Aug. 13.1	Aug. 13.5	Aug. 13.6
Cape Chacon to Point										
Marsh Section	Aug. 28									Aug. 15.4
South Prince of Wales										
Island District										
Northwestern Section	Aug. 28								Aug. 18.0	Aug. 17.4
Southeastern Section	Aug. 28									Aug. 15.7
Southern District										
Behm Canal Section	Aug. 19							Aug. 2.5		
Revillagigedo	Aug. 19				Aug. 11.6	Aug. 12.7	Aug. 8.7	Aug. 12.4	Aug. 10.7	Aug. 7.7



## PINK SALMON RUNS

TABLE I (continued)

[illegible]

TABLE I (continued)  
DATES UPON WHICH SEVENTY-FIVE PER CENT OF THE PINK SALMON TRAP CATCH HAD BEEN MADE UP TO AND INCLUDING THE TRUNCATION DATE, BY  
DISTRICTS, SOUTHEASTERN ALASKA.

District and Section	Truncation Date	1926	1928	1930	1932	1934	1936	1938	1940	1942	1944
Icy Strait District	Aug. 5	July 26.9	July 30.2	July 28.3	Aug. 1.4	July 29.8	July 31.1	Aug. 1.7	•Aug. 5.1	Aug. 3.0	Aug. 2.8
Western Section	Aug. 7	July 29.0	July 30.5	Aug. 4.3	Aug. 4.3	Aug. 2.4	Aug. 1.6	Aug. 4.3	Aug. 6.1	Aug. 5.7	Aug. 4.1
Eastern Section											
Western District	Aug. 11	July 27.9	Aug. 2.7	Aug. 6.5	Aug. 5.9	Aug. 8.7	Aug. 5.4	Aug. 8.9	Aug. 7.1	Aug. 10.4	Aug. 10.1
Northern Section	Aug. 15	July 28.6	Aug. 2.7	Aug. 8.0	Aug. 12.1	Aug. 13.1	Aug. 13.8	Aug. 12.7	Aug. 13.7	Aug. 14.1	Aug. 13.1
North-Central Section	Aug. 19	Aug. 5.3	Aug. 10.6	Aug. 7.8	Aug. 15.8	Aug. 17.2	Aug. 14.1	Aug. 17.3	Aug. 16.1	Aug. 16.5	Aug. 18.1
South-Central Section	Aug. 19	Aug. 1.9	Aug. 6.6	Aug. 8.8	Aug. 15.9	Aug. 16.8	Aug. 15.7	Aug. 16.9	Aug. 15.7	Aug. 17.4	Aug. 18.0
Southern Section											
Eastern District	Aug. 14	July 30.0	Aug. 3.5	Aug. 10.6	Aug. 9.3	Aug. 7.4	Aug. 11.2	Aug. 5.2	.....	.....	.....
Northern Section	Aug. 19	Aug. 4.3	Aug. 6.9	Aug. 11.6	Aug. 15.5	Aug. 14.3	Aug. 13.2	Aug. 16.4	Aug. 15.5	Aug. 17.2	Aug. 16.9
Central Section	Aug. 19	Aug. 4.6	Aug. 7.2	Aug. 10.2	Aug. 15.2	Aug. 13.6	Aug. 7.0	Aug. 14.3	Aug. 15.7	Aug. 16.5	Aug. 15.1
Southern Section											
Summer Strait District											
W. Coast Prince of Wales											
Island Section	Aug. 23	Aug. 8.3	Aug. 12.2	Aug. 17.4	Aug. 19.9	Aug. 19.5	Aug. 17.9	Aug. 19.0	Aug. 20.0	Aug. 20.3	Aug. 19.9
Summer Strait Section	Aug. 23	Aug. 10.8	Aug. 12.5	Aug. 15.3	Aug. 19.1	Aug. 16.0	Aug. 17.5	Aug. 19.0	Aug. 20.6	Aug. 20.0	Aug. 19.3
Snow Passage Section	Aug. 23	Aug. 9.9	.....	Aug. 10.4	Aug. 7.7	Aug. 13.0	Aug. 16.4	Aug. 18.2	Aug. 19.8	Aug. 18.5	Aug. 16.2
Ernest Sound Section	Aug. 19	Aug. 3.4	Aug. 9.3	Aug. 6.7	Aug. 16.2	Aug. 4.0	Aug. 13.5	Aug. 15.7	Aug. 13.3	July 29.8	July 28.5
Clarence Strait District											
Northern Section	Aug. 29	Aug. 9.8	Aug. 16.2	Aug. 15.8	Aug. 20.0	Aug. 20.7	Aug. 21.3	Aug. 26.9	Aug. 22.6	Aug. 25.0	Aug. 25.1
Central Section	Aug. 26	Aug. 6.7	Aug. 19.1	Aug. 14.7	Aug. 22.7	Aug. 20.2	Aug. 18.1	Aug. 23.6	Aug. 19.4	Aug. 21.4	Aug. 22.9
Southeastern Section	Aug. 23	Aug. 5.2	Aug. 9.0	Aug. 12.3	Aug. 17.8	Aug. 16.7	Aug. 17.4	Aug. 18.7	Aug. 20.1	Aug. 18.1	Aug. 20.1
Approach Pt. to Cape											
Chacon Section	Aug. 23	Aug. 9.4	Aug. 15.7	Aug. 17.8	Aug. 21.0	Aug. 19.4	Aug. 18.8	Aug. 20.1	Aug. 20.1	Aug. 19.6	Aug. 19.8
Cape Chacon to Point											
Marsh Section	Aug. 28	Aug. 6.5	.....	Aug. 20.2	.....	Aug. 17.2	Aug. 18.5	Aug. 23.0	Aug. 20.0	Aug. 22.0	Aug. 22.5
South Prince of Wales											
Island District											
Northern Section	Aug. 28	Aug. 11.8	Aug. 17.4	Aug. 19.4	Aug. 24.3	Aug. 22.6	Aug. 21.4	Aug. 24.7	Aug. 22.8	Aug. 25.6	Aug. 24.8
Southern Section	Aug. 28	Aug. 11.6	Aug. 17.6	Aug. 22.0	Aug. 22.7	Aug. 20.9	Aug. 21.6	Aug. 23.8	Aug. 22.4	Aug. 25.2	Aug. 24.8
Southern District											
Barren Island Section	Aug. 19	Aug. 4.1	Aug. 9.4	Aug. 11.7	Aug. 15.4	Aug. 9.9	Aug. 9.3	Aug. 13.8	Aug. 10.6	Aug. 15.8	Aug. 13.8
Revillagigedo	Aug. 19	Aug. 5.7	Aug. 6.6	Aug. 11.8	Aug. 21.3	Aug. 14.4	Aug. 12.5	Aug. 15.8	Aug. 13.8	Aug. 14.6	Aug. 14.9

## PINK SALMON RUNS

TABLE I (continued)

	1927	1929	1931	1933	1935	1937	1939	1941	1943	1945
Icy Strait District	Aug. 5	July 26.9	July 30.8	Aug. 1.2	July 29.2	July 29.1	July 31.5	July 29.4	Aug. 2.1	Aug. 1.8
Western Section	Aug. 7	July 30.3	Aug. 3.7	Aug. 1.4	July 30.1	Aug. 1.6	Aug. 1.8	Aug. 3.0	Aug. 4.0	Aug. 2.8
W. Coast Prince of Wales										
Northern Section	Aug. 11	July 26.4	Aug. 1.0	July 20.8	Aug. 4.2	Aug. 5.1	Aug. 3.9	July 31.9	Aug. 10.0	Aug. 8.3
North-Central Section	Aug. 15	Aug. 1.0	Aug. 7.0	Aug. 8.8	Aug. 9.2	Aug. 12.9	Aug. 14.1	Aug. 10.7	Aug. 12.8	Aug. 8.3
South-Central Section	Aug. 18	Aug. 9.0	Aug. 4.3	Aug. 11.0	Aug. 14.3	Aug. 13.6	Aug. 16.8	Aug. 13.8	Aug. 16.3	Aug. 15.8
Southern Section	Aug. 19	Aug. 4.4	Aug. 7.6	Aug. 16.1	Aug. 12.5	Aug. 13.6	Aug. 13.4	Aug. 13.9	Aug. 15.9	Aug. 16.0
Eastern District										
Northern Section	Aug. 14	Aug. 1.3	Aug. 5.2	.....	Aug. 5.4	Aug. 8.3	Aug. 6.3	.....	.....	.....
Central Section	Aug. 19	Aug. 7.9	Aug. 10.8	Aug. 11.3	Aug. 5.9	Aug. 10.7	Aug. 14.3	Aug. 13.6	.....	Aug. 15.9
Southern Section	Aug. 19	Aug. 7.4	Aug. 9.7	Aug. 9.3	Aug. 8.7	Aug. 3.3	Aug. 13.4	Aug. 12.5	Aug. 13.2	Aug. 15.9
Summer Strait District										
W. Coast Prince of Wales										
Island Section	Aug. 23	Aug. 16.3	Aug. 16.2	Aug. 18.0	Aug. 15.3	Aug. 18.5	Aug. 18.2	Aug. 18.9	Aug. 20.4	Aug. 21.6
Summer Strait Section	Aug. 23	Aug. 17.9	Aug. 12.2	Aug. 13.7	Aug. 9.0	Aug. 17.5	Aug. 18.2	Aug. 17.5	Aug. 19.0	Aug. 20.8
Snow Passage Section	Aug. 23	Aug. 11.7	Aug. 7.1	Aug. 6.9	Aug. 13.0	Aug. 17.2	Aug. 18.8	Aug. 16.0	Aug. 19.2	Aug. 20.4
Ernest Sound Section	Aug. 19	Aug. 16.3	Aug. 6.0	Aug. 9.8	Aug. 2.9	Aug. 7.6	Aug. 6.6	Aug. 3.9	.....	Aug. 2.7
Clarence Strait District										
Northern Section	Aug. 29	Aug. 15.6	Aug. 15.1	Aug. 18.4	Aug. 20.6	Aug. 23.6	Aug. 24.5	Aug. 22.9	Aug. 26.5	Aug. 26.7
Central Section	Aug. 26	Aug. 16.2	Aug. 15.5	Aug. 18.7	Aug. 16.5	Aug. 20.7	Aug. 21.0	Aug. 20.8	Aug. 22.1	Aug. 22.0
Southeastern Section	Aug. 23	Aug. 9.9	Aug. 10.0	Aug. 18.0	Aug. 16.2	Aug. 17.2	Aug. 18.9	Aug. 17.7	Aug. 20.2	Aug. 21.2
Approach Pt. to Cape										
Chacon Section	Aug. 23	Aug. 11.8	Aug. 11.8	Aug. 18.7	Aug. 18.6	Aug. 18.2	Aug. 20.6	Aug. 18.9	Aug. 20.1	Aug. 21.1
Cape Chacon to Point										
Marsh Section	Aug. 28	Aug. 16.2	Aug. 11.6	Aug. 21.5	Aug. 20.3	Aug. 20.2	Aug. 21.4	Aug. 19.1	Aug. 24.5	Aug. 24.0
South Prince of Wales										
Island District										
Northwestern Section	Aug. 28	Aug. 17.3	Aug. 20.6	Aug. 24.8	Aug. 21.9	Aug. 23.2	Aug. 24.5	Aug. 24.2	Aug. 26.0	Aug. 26.5
Southeastern Section	Aug. 28	Aug. 16.6	Aug. 14.5	Aug. 25.0	Aug. 22.4	Aug. 23.9	Aug. 25.1	Aug. 24.1	Aug. 27.0	Aug. 26.1
Southern Section										
Behm Canal Section	Aug. 19	Aug. 10.6	Aug. 8.3	Aug. 11.1	Aug. 8.0	Aug. 11.0	Aug. 13.7	Aug. 11.2	Aug. 13.5	Aug. 15.2
Revillagredo Section	Aug. 19	Aug. 5.7	Aug. 7.7	Aug. 6.5	Aug. 9.5	Aug. 13.3	Aug. 11.1	Aug. 10.6	Aug. 12.3	Aug. 14.9

divided into nine districts for the purpose of regulating the commercial fisheries by the Fish and Wildlife Service.<sup>2</sup> For the purpose of this analysis these districts have been sub-divided into 22 sections.

Before 1924, the traps fished as long as they could catch salmon; therefore the time of the catch and the run corresponded. Following that year the curves of the season's catches were truncated because of the closing dates on fishing. Since our index is the date on which 75 per cent of the

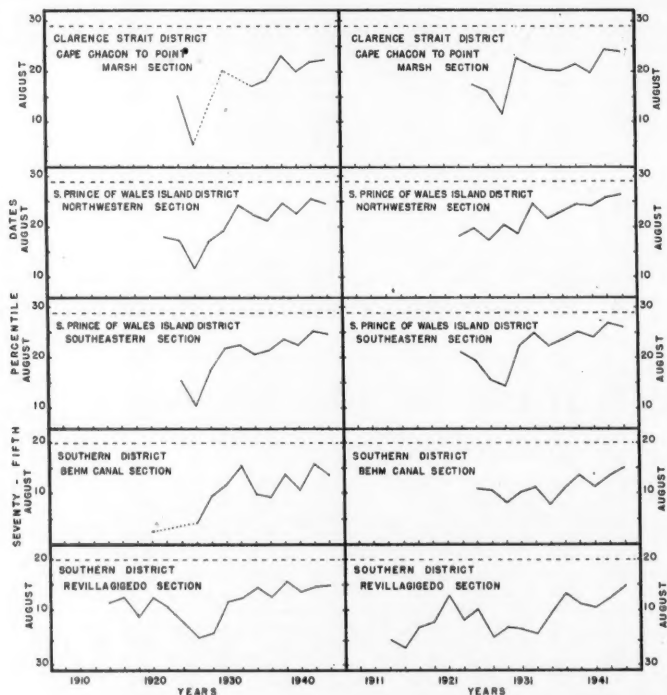


Fig. 4. Dates by which 75 per cent of the pink salmon trap catches have been made, even and odd year cycles, Clarence Strait, South Prince of Wales Island and Southern districts of southeastern Alaska. (Truncation date shown by broken horizontal line.)

catch was made, following 1924 the index is not as late as it would have been had the season remained open to fishing. The closing date places a limit on the value of the index. In order to obtain a more accurate index a detailed study of the frequency curve of the daily average trap catch should be made and the influence the closing date has on the index. However, the index, as here defined, gives a general picture of the time when the pink salmon run appears in each section of southeastern Alaska. As the closing date has

<sup>2</sup> These fishing districts are defined in "Laws and regulations for protection of commercial fisheries of Alaska, 1945," published by the Fish and Wildlife Service, Washington, D. C. Since the basis of this discussion is the daily catch records of traps, and since traps are not permitted to operate in the Yakutat and Sitka districts, these two districts have been omitted from the discussion.

varied from year to year, the truncation date was chosen for each section so that the limit on the index will be constant from year to year. Thus the index is the date on which 75 per cent of the run appearing before and on the truncation date, had been caught by the traps in the area. Table I gives the truncation date for each section and also the value of the index for each year that data are available. These indices are plotted in Figures 1 to 4, the truncation date being indicated by the horizontal broken line.

TABLE II

SLOPES OF THE REGRESSION LINES OF THE SEVENTY-FIFTH  
PERCENTILE DATE ON TIME, IN DAYS PER CYCLE

District and Section	Even Years		Odd Years	
	<i>b</i>	$\sigma b$	<i>b</i>	$\sigma b$
Icy Strait District				
Western Section	0.80	0.14	0.78	0.27
Eastern Section	0.96	0.10	0.93	0.12
Western Section				
Northern Section	1.44	0.19	0.92	0.33
North Central Section	1.58	0.26	1.45	0.23
South Central Section	1.97	0.39	1.96	0.44
Southern Section	1.33	0.18	1.19	0.22
Eastern District				
Northern Section	1.36	0.42	1.73	0.45
Central Section	1.05	0.28	0.75	0.26
Southern Section	1.47	0.21	0.94	0.18
Sumner Strait District				
West Coast Prince of Wales Island Section	0.77	0.17	0.63	0.12
Sumner Strait Section	0.97	0.14	0.90	0.17
Snow Passage Section	1.54	0.59	0.82	0.26
Ernest Sound Section	-0.41	0.64	-0.19	0.57
Clarence Strait District				
Northern Section	0.94	0.24	0.86	0.13
Central Section	0.88	0.20	0.54	0.10
Southeastern Section	0.79	0.18	0.85	0.12
Approach Point to Cape Chacon	0.65	0.15	0.84	0.13
Cape Chacon to Point Marsh Section	1.10	0.36	0.76	0.27
South Prince of Wales Island Section				
Northwestern Section	0.93	0.21	0.78	0.12
Southeastern Section	1.06	0.22	0.80	0.22
Southern District				
Behm Canal Section	0.44	0.25	0.91	0.16
Revillagigedo Section	0.41	0.14	0.34	0.12

A theoretical relationship would not be expected to exist between seasons and the time that the pink salmon run appeared during these seasons, except as biological and meteorological factors affecting the run are correlated with the seasons.

To smooth these data and determine any general trend with time, orthogonal polynomials were fitted by Fisher's methods.<sup>3</sup> The success of fitting terms of higher and higher degree was observed and tested for significance at each stage. In the majority of cases, curves of higher degree than the first did not reduce the standard error of estimate significantly. The slopes of the linear regression of the index on time, in days per cycle, are given in Table II. Except for Ernest Sound section of Sumner Strait District and

<sup>3</sup> Fisher, R. A., Statistical Methods for Research Workers, 9th Ed. Oliver and Boyd, London. 1944.

the even-year population in the Behm Canal section of Southern District, the runs, on the average, have been appearing later in the season each year.

Since data for the Eastern section of the Icy Strait District are available as early as 1908, a line was fitted to the indices of the untruncated data for years preceding 1924, and to the indices of the truncated data for the years preceding and following 1924. The slopes of these three lines are as follows:

	EVEN YEARS	ODD YEARS
Years preceding 1924, untruncated data	1.52	0.56
Years preceding 1924, truncated data	0.89	0.53
Years following 1924, truncated data	0.61	0.33

That the slopes of the lines for the period following 1924 are less than for the period prior to 1924 does not necessarily imply that the rate at which the runs are getting later has been retarded. It must be remembered that as the season becomes later, the indices approach the truncation date and are limited by it. However these data do indicate that this phenomenon of the runs appearing later in the season as the years progress had begun before the curtailment of the fishing season.

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## The Genetic Fixity of Differential Characters in Subspecies of the Percid Fish, *Boleosoma nigrum*<sup>1</sup>

By KARL F. LAGLER and REEVE M. BAILEY

ONE of the most interesting developments of the numerous recent studies of speciation centers in the recognition of ecologically separated subspecies. Among North American fresh-water fishes the mimic shiner, *Notropis volucellus*, provides perhaps the best example so far brought to light (Trautman, 1931). In this species, one subspecies lives in small streams and lakes, a second in quiet backwaters of large rivers, a third in the open channels of the rivers—all within the same geographic area. The morphological differences among these subspecies are greater than those between many species of cyprinids, but intergradation occurs in the borderline areas where the ecological niches are contiguous.

The two races of the Johnny darter which provide the experimental material for this report have their own characteristic geographic distributions, but in the region where they both occur may be regarded as ecological subspecies. The geographic range of the scaly Johnny darter, *Boleosoma nigrum eulepis* Hubbs and Greene, 1935, lies wholly within that of the central Johnny

<sup>1</sup> Contribution from the Laboratory of Vertebrate Biology, the Museum of Zoology, and the Department of Zoology of the University of Michigan.

darter, *Boleosoma n. nigrum* (Rafinesque, 1820). The latter occurs from Hudson Bay to the Gulf of Mexico, and from the Appalachian Highlands to the Rocky Mountains. *B. n. eulepis* is found from Minnesota and northern Iowa, east in the glacial-lake belt to southern Ontario, northern Ohio, and northern Pennsylvania; an isolated population occurs in the Neosho River drainage of southwestern Missouri. Within this range, however, *eulepis* does not hold forth to the exclusion of *nigrum*, but is found in more or less discontinuous pockets or foci of abundance, surrounded by peripheral areas of intergradation, which are in turn succeeded by regions populated by the typical subspecies. In Michigan, *eulepis* is found principally in the estuaries of the rivers tributary to the Great Lakes (except Superior), in Indian Lake near the southern edge of the Upper Peninsula, in the lower Saginaw River, and in Lake St. Clair and the Detroit River. These are base-level waters, rather extensive, and quiet or slow-moving. They are further characterized by moderate or dense growths of aquatic vegetation, and bottoms composed at least in part of mud or silt. Most of the rest of the state is pre-empted by *nigrum*. Not only does this form occur in most streams, but it invades lakes, where it is found typically in areas subject to moderate wave action. The typical subspecies prefers a firmer substratum than does *eulepis*. Where the ranges of the two forms overlap in single streams in northern Ohio, segregation occurs during the breeding season, at which time *nigrum* works upstream, according to a verbal report by Milton B. Trautman. The distribution of these fishes in Wisconsin has been discussed in detail by Greene, 1935.

We are indebted to Drs. Charles Cotterman, Ralph Hile, and A. F. Shull for suggestions of value regarding the mathematical interpretation of the results, and to Dr. Lee R. Dice who read the manuscript. For furnishing *Artemia* during the experimental phase of the problem we are very grateful to Dr. Wilbert M. Chapman of the Steinhart Aquarium.

#### OBJECTIVES

Critics of certain recent taxonomic studies have questioned, not without justification, the systematists' tacit assumption that differences discovered between individuals or series of specimens are *ipso facto* genetic. The need for objective evaluation of the interplay of genetic *versus* environmental factors in the production of morphological *differentiae* employed by modern systematists is emphasized by the recognition that meristic characters may be modified by environmental factors—especially temperature differentials during development; and that malnutrition may produce abnormalities in form, proportions, and coloration. This study was initiated in an attempt to evaluate such factors in the two ecologic subspecies of *Boleosoma nigrum* found in Michigan. Are the differential characters of these forms the result of their diverse ecologic habitats or are they truly heritable?

If, when the offspring of the two subspecies are hatched and reared under virtually identical environmental conditions, they differ as greatly as do the parental populations, it will be apparent that the characters are heritable. If they do not differ significantly, the structural differences may be regarded as under strict environmental control. If the observed differences are notably less well marked than between the parental populations, an inter-



action of genetic and environmental factors may be assumed to be involved in the determination of characters.

#### METHODS

Field-captured fish of the two subspecies were brought into the laboratory prior to the breeding season in the spring of 1945. The stock of *B. n. nigrum* was secured in the headwaters of the Saline River, about 3 miles west of Saline, Washtenaw County, Michigan. It is demonstrated from study of the numerous available collections in this general area that *nigrum* occurs to the exclusion of *eulepis*, and the stock is typical of *nigrum* as this form occurs in southern Michigan. The Detroit River at Belle Isle, Detroit, Michigan, yielded the stock of *eulepis*. At various localities in the Detroit River and Lake St. Clair there appears to be an admixture of *nigrum*; some of these populations are best classified as intergrades, *Boleosoma nigrum*: *eulepis*  $\times$  *nigrum*, and others are rather typical of *nigrum*. The Belle Isle stock is characteristic of *eulepis* and is therefore regarded as suitable for our work.

The fish were conditioned to laboratory temperature and were mated immediately. The four possible combinations were used: both intrasubspecific matings and the reciprocal crosses. One male and 2 or 3 females were placed in each aquarium.

These aquaria are rectangular, 8 by 13 inches, with a depth of 9 inches; they have a 16-quart capacity. The aquaria were prepared with a mixed sand and gravel bottom, a light growth of *Vallisneria americana*, dechlorinated tapwater, and forced-air aerators. Water movement was limited to the gentle currents produced by the air diffusers. Each aquarium was equipped with a flat slab of stone, elevated at one edge to simulate the natural type of spawning site selected by this species—which lays its adhesive eggs in a layer on the flattened lower side of an object. The aquaria were placed in a single wooden trough along the north wall of the room (which has windows only along the south wall), and electric bulbs were so arranged as to provide approximately uniform illumination to all. Cold tapwater was run through the trough to serve as a water-jacket to assure nearly uniform temperature and to minimize daily fluctuations. Temperatures were recorded twice daily from maximum and minimum thermometers. After hatching, some of the tanks of each subspecies were removed from the water-jacket and kept at room temperature.

Johnny darters proved willing subjects for experimentation and spawned freely within a few days after they were mated. The males guarded the eggs faithfully, and seemed only temporarily disturbed when the spawning slabs were moved to permit examination of the developing eggs. Immediately after the eggs hatched, the adults were removed from the aquaria to prevent possible cannibalism.

Rearing the young proved to be the most difficult phase of the experimental work. Non-living food was rejected or taken only occasionally. Since very small, live organisms were required, the nauplii of the brine shrimp, *Artemia salina*, were employed. These were strained from their salt-water hatching tanks, rinsed in fresh water, and fed twice daily to the young darters. Natural plankton was used only when the available supply of *Artemia* eggs was temporarily exhausted. Periodically the young fish were moved to fresh, balanced aquaria in order to thin their numbers, to make fry counts, or because of fouling of the tanks. Considerable loss was experienced as a result of faulty manipulation, failure of aerators, and unknown causes. Nevertheless, substantial numbers were reared to suitable sizes for this study of

morphological characters. Almost all fish still living were preserved on September 8, 1945.

*Boleosoma nigrum eulepis* has been shown to differ from *B. n. nigrum* chiefly in the more extensive squamation of the nape, cheeks, and breast (Hubbs and Greene, 1935). The additional feature of the better developed ctenii on the scales in *eulepis* does not lend itself to facile quantification so we have not attempted to compare the forms in this character. We do contrast the extent of scutellation on the areas named above in the two parental populations, the first generation offspring of each subspecies, and in the few available fish resulting from the intersubspecific crosses.

The nape, breast, and cheeks vary in our material from wholly naked to almost or completely scaled. In order to arrive at a quantitative measure of the distribution of scales in each area we have estimated the approximate percentage of the area covered. Examination was made with bright illumination under a binocular dissecting microscope. A stream of compressed air was played over the area, which was also scratched with a needle to reveal imbedded scales. The nape was recorded as naked when there were no scales from the occiput to origin of the dorsal fin, and for a breadth of about one-fourth the distance between the lateral lines (as measured over the curve of the back). If scales were present on this surface the area covered was estimated to the nearest 10 per cent. The breast was treated in the same way, its extent being delimited by the bases of the pelvic fins and the branchiostegal membranes. Since scales are present on the cheek only over its fleshy surface (not on the preopercle), a complete investment of this area would be recorded as 100 per cent. Actually, every individual had at least a narrow naked strip just above the anterior portion of the horizontal arm of the preopercle, and none was recorded as more than 90 per cent scaled. A cheek with a single scale, or two or three very small ones, was regarded as 5 per cent scaled.

#### INHERITANCE OF SQUAMATION

*Nape.*—It is characteristic of the region between the dorsal fin and the occiput to be almost or completely scaled in *eulepis* (Hubbs and Greene, 1935: 99). The 50 specimens examined from our parental stock are all fully scaled. Only 2 of the 34 specimens of the experimentally reared *eulepis* are incompletely scaled (see Table I). In *nigrum* the nape varies in the parental stock from 0 to 30 (70) per cent scaled (mean,  $13.7 \pm 1.7$  per cent); in the offspring the comparable figures are 0 to 60 (mean,  $13.0 \pm 1.8$ ). The 5 fish produced by an intersubspecific cross<sup>2</sup> are from 80 to 90 per cent scaled on the nape, mean 88 per cent, a figure closer to the usual condition in *eulepis* than to that in *nigrum*.

*Cheek.*—In *nigrum* the cheek is usually wholly naked or has one scale near its upper border behind the eye; in some specimens there are two or more scales, but these are most often small and imbedded (see Table II). Only rarely is the area behind the eye covered with scales, and the lower portion of the cheek is always scaleless. It is possible that small imbedded scales were occasionally overlooked in spite of our efforts to locate them. The mean

<sup>2</sup> Although a number of crosses were made, only one produced young which survived to a satisfactory size for the study of characters. Faculty technique was in part responsible, and the data are too fragmentary to indicate the degree of fertility in the crosses as compared with the intraspecific matings.

TABLE I  
FREQUENCY DISTRIBUTION OF ESTIMATED PERCENTAGES OF EXTENT OF NAPE SQUAMATION IN *Boleosoma nigrum*

Genetic group	Percentage of squamation of nape											Number of specimens	Mean percentage	Standard error
	0	10	20	30	40	50	60	70	80	90	100			
<i>nigrum</i>														
Parental stock	9	24	11	5	..	..	..	1	..	..	..	50	13.7	±1.7
Offspring	19	27	8	3	..	2	2	..	..	..	..	63	13.0	±1.8
<i>eulepis</i> × <i>nigrum</i>														
Offspring	..	..	..	..	..	..	..	..	1	4	..	5	88.0	±2.0
<i>eulepis</i>														
Parental stock	..	..	..	..	..	..	..	..	..	..	50	50	100.0	±0.0
Offspring	..	..	..	..	..	..	..	1	1	..	32	34	98.5	±1.0

TABLE II  
FREQUENCY DISTRIBUTION OF ESTIMATED PERCENTAGES OF EXTENT OF CHEEK SQUAMATION IN *Boleosoma nigrum*  
The data for both cheeks are given.

Genetic group	Percentage of squamation of cheek											Number of cheeks	Mean percentage	Standard error	
	0	5	10	20	30	40	50	60	70	80	90				
<i>nigrum</i>															
Parental stock	91	8	1	..	..	..	..	..	..	..	..	100	0.5	±0.2	
Offspring	99	18	3	5	1	..	..	..	..	..	..	126	2.0	±0.5	
<i>eulepis</i> X <i>nigrum</i>															
Offspring	..	..	..	..	4	6	..	..	..	..	..	10	36.0	±1.6	
<i>eulepis</i>															
Parental stock	..	..	1	1	1	3	11	18	31	20	14	100	68.4	±1.6	
Offspring	4	3	3	6	1	2	3	9	13	13	11	68	57.6	±3.5	

TABLE III  
FREQUENCY DISTRIBUTION OF ESTIMATED PERCENTAGES OF EXTENT OF BREAST SQUAMATION IN *Boleosoma nigrum*

Genetic group	Percentage of squamation of breast											Number of specimens	Mean percentage	Standard error
	0	10	20	30	40	50	60	70	80	90	100			
<i>nigrum</i>														
Parental stock	50	..	..	..	..	..	..	..	..	..	..	50	0.0	±0.0
Offspring	62	1	..	..	..	..	..	..	..	..	..	63	0.2	±0.2
<i>eulepis</i> × <i>nigrum</i>														
Offspring	..	..	..	1	1	..	2	1	..	..	..	5	52.0	±7.3
<i>eulepis</i>														
Parental stock	..	..	..	..	..	..	..	2	2	5	41	50	97.1	±1.0
Offspring	..	..	..	..	..	..	1	3	4	2	24	34	93.2	±2.0

TABLE IV  
RELATIONSHIP OF SQUAMATION ON THE BREAST AND ON THE CHEEK IN *Boleosoma nigrum eulepis*

Percentage of breast scaled	Percentage of cheek scaled											Number of checks	Mean percentage
	0	5	10	20	30	40	50	60	70	80	90		
60	2	..	1	..	..	1	1	1	..	..	..	2	0.0
70	1	1	1	4	..	1	1	1	..	..	..	10	24.5
80	1	2	3	1	1	1	..	3	1	..	..	12	28.3
90	..	..	..	2	1	..	6	3	1	..	..	14	47.1
100	..	..	..	..	..	3	7	20	42	33	25	130	73.0

values for parental stock and offspring are  $0.5 \pm 0.2$  and  $2.0 \pm 0.5$  per cent, respectively.

In *eulepis* the cheek is normally at least half-scaled, but even if the figure is smaller the scales are typically large, ctenoid, and exposed—in sharp contrast to those of *nigrum*. The respective mean values for parental stock and offspring are  $68.4 \pm 1.6$  and  $57.6 \pm 3.5$  per cent of the area; there is only about one chance in 400 that the populations have been made to appear different by the accidents of random sampling. Two possible explanations of the difference may be considered: the reduction in scales is (1) an indication of a changed environment, or (2) due to an unrepresentative sampling of the  $F_1$  generation. In support of the second alternative, it should be noted that 29 of the 34 fish in this category are the product of one mating consisting of one male and 3 females. If one or more of these parents were near the lower genetic limit of normal variation in the character, transmission of the atypical condition to the offspring could easily produce the deviation noted. The five specimens produced from another mating had a mean value of 74.0 per cent as compared with 54.7 per cent in the group of 29 fish. The need for more data is apparent; these we hope to secure in the continuation of the studies. For the present we tentatively assume that the variation is the result of unrepresentative sampling in the  $F_1$  generation.

The laboratory-produced intergrades have a variation in squamation of from 30 to 40 per cent of the area of the cheek, mean  $36.0 \pm 1.6$  per cent. This is almost exactly halfway between the 0.5 and 68.4 per cent values in the parental stocks of *nigrum* and *eulepis* respectively, and is in line with the phenotypic intermediacy repeatedly shown by fish hybrids.

*Breast.*—In the stocks studied, the subspecies are most sharply differentiated in the degree of squamation of the breast (see Table III). None of 50 specimens of the parental stock of *nigrum* was found to have any scales on this ventral area; 62 of 63 offspring are also naked here—the sole exception has about 4 small imbedded scales. Most of the *eulepis* are fully scaled, and none is less than 60 per cent covered. The mean values for the parental stock and  $F_1$  generation are  $97.1 \pm 1.0$  and  $93.2 \pm 2.0$  per cent, respectively. Since there is an apparent linkage in the characters of scutellation of breast and cheek in *eulepis* ( $r$  values highly significant, Table V), the explanation for this inequality in values is the same as that given for the difference in extent of cheek scales in the same stocks.

The breasts of the experimentally-produced intergrades vary in their squamation from 30 to 70 per cent, mean  $52.0 \pm 7.3$  per cent. This value is about halfway between the 0 and 97.1 per cent figures for the stocks of *nigrum* and *eulepis* respectively.

#### CORRELATION OF SQUAMATION ON NAPE, CHEEK, AND BREAST

As noted above, *nigrum* and *eulepis* differ chiefly in the development of scales on specified areas; in each, *nigrum* is typically naked or has few scales, whereas *eulepis* is well, if not fully, scaled. In order to test these three characters to see whether they are independent or are linked, Tables IV and VI have been prepared and the correlation coefficients computed (Tables V and VII). For this purpose the parental stocks and offspring were treated separately and then combined for each subspecies. In Tables IV and VI, esti-

mates of both cheeks are given, since the data for both cheeks were originally recorded to strengthen the sample size. They are separated in Tables V and VII, and the  $r$  values based on left cheeks alone would be adequate; the slight differences between right and left are probably due to the method of estimation.

TABLE V

CORRELATION COEFFICIENTS ( $r$ ) FOR RELATIONSHIP BETWEEN BREAST AND CHEEK SQUAMATION IN *Boleosoma nigrum eulepis*

Source of variation	Degrees of freedom	$r$ left cheek to breast	$r$ right cheek to breast	$r$ at 1% level of significance
Parental stock	48	0.616	0.481	0.361
Offspring	32	0.840	0.868	0.437
Parental stock and offspring, combined	82	0.775	0.749	0.280

TABLE VI

RELATIONSHIP OF SQUAMATION ON THE NAPE AND ON THE CHEEK IN *Boleosoma n. nigrum*

Percentage of nape scaled	Percentage of cheek scaled					Number of cheeks	Mean percentage
	0	5	10	20	30		
0	55	1	..	..	..	56	0.1
10	86	9	2	4	1	102	1.7
20	35	4	..	..	..	38	0.4
30	10	6	..	..	..	16	1.9
40	1	3	..	..	..	4	3.8
50	2	2	..	..	..	4	2.5
60	..	1	2	1	..	4	11.3
70	1	1	..	..	..	2	2.5

TABLE VII

CORRELATION COEFFICIENTS ( $r$ ) FOR RELATIONSHIP BETWEEN NAPE AND CHEEK SQUAMATION IN *Boleosoma n. nigrum*

Source of variation	Degrees of freedom	$r$ left cheek to nape	$r$ right cheek to nape	$r$ at 5% level of significance	$r$ at 1% level of significance
Parental stock	48	0.279	0.342	0.279	0.361
Offspring	61	0.250	0.306	0.248	0.323
Parental stock and offspring, combined	111	0.230	0.284	0.186	0.243

In *eulepis* the nape is almost invariably scaled so the data permit comparison only between squamation of the breast and cheek. It is clear from examination of Tables IV and V that there is a highly significant positive correlation between development of scales on these areas. The  $r$  values are well above the one per cent level of significance. No specimen in which the

breast is incompletely scaled has more than 70 per cent of either cheek scaled; whereas, the mean for those with fully scaled breasts is 73.0 per cent, and some have as much as 90 per cent of the cheek covered.

In *nigrum* the breast is so uniformly naked as to preclude comparison with the other areas, but the data on the scutellation of the cheek and the nape are contrasted in Tables VI and VII. Those fish with naked napes almost without exception have naked cheeks as well; those with partially scaled napes often have one or a few scales, but scaleless cheeks predominate in all classes in which the nape is less than 30 per cent scaled. On the 7 individuals with 40 to 70 per cent of the nape scaled, there are 10 cheeks with one or more scales and 4 are bare. The data, though not as clear-cut as those on relationship of breast and cheek scales in *eulepis*, still indicate a positive correlation in the squamation of nape and cheek in *nigrum* (all six values of  $r$  are significant at the 5 per cent level).

#### CONCLUSIONS

The first generation offspring of *Boleosoma n. nigrum* and *B. n. eulepis* which were hatched and reared under uniform environmental conditions in the laboratory, differ from each other in the same characters of squamation and to virtually the same degree as do the parental populations. In *nigrum* no significant differences were noted between the parents and their offspring, and the scutellation of the nape in *eulepis* is identical in the offspring and the parents. In squamation of the cheeks and breast the  $F_1$  *eulepis* show a slight but appreciable approach toward the less completely scaled condition in *nigrum*. This deviation is believed to result from an unrepresentative sample in the  $F_1$  generation, most of which came from a single mating of one male with three females. One or more of this small group of parents may have been genetically near the limit of the range of variation for the subspecies.

Since the differential features in these subspecies persist when the fish develop under identical environmental conditions, the characters are regarded as genetically fixed.

The scutellation on the nape, the cheek, and the breast, although considered as different characters, appear to be the multiple manifestation of concerted genic action. In *eulepis* there is a positive correlation between scale development on the cheek and on the breast; a fully scaled nape is characteristic. In *nigrum*, the squamation of the nape and of the cheek are also genetically interdependent; the breast is almost invariably naked.

In view of the phenotypic intermediacy of the  $F_1$  intergrades, it may be concluded that the genetic difference between the subspecies is not to be explained as simple dominance.

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DEPARTMENT OF ZOOLOGY and MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN.

## A New Genus of Deepsea Fish from the Gulf of Panama<sup>1</sup>

By A. E. PARR

WHEN the writer first saw the arrangement of the jaws in *Mirorictus tåningi* he was inclined to view it with disbelief or with a strong suspicion that he was merely observing the traumatic or teratological condition of an aberrant specimen. The closest scrutiny has failed to reveal any evidence to sustain these suspicions, and has given abundant indication that the conditions observed in the type probably do represent the normal state of the species.

The specimen shows none of the asymmetries that are so commonly associated with teratological malformations and that are almost always present in conditions caused by injury. Dislocation at the joints of the lower jaw is excluded as an explanation. The palate is much too low to admit the high ascending rami of the lower jaws under its roof. Access to the mouth for the lower jaw is blocked by the wide, inwardly turned surfaces of the maxillaries. In short, it would not be a minor, but a very major change in the anatomy of the mouth parts that would be required to bring the upper and lower jaws into the relationship normally found among teleosts, nevertheless there is not the slightest suggestion of individual abnormality to be found about the specimen. The introduction of a new genus therefore seems justified and necessary.

Apart from the peculiar morphology of the jaws, *Mirorictus* would seem a typical member of the Alepocephalidae so far as external characters and abdominal organs are concerned, and it is therefore referred to this family. The arrangement of the jaws is, of course, unique, not only among the alepocephalids, but also among all other teleosts seen by the writer. In general form *Mirorictus* would otherwise seem close to *Alepocephalus*, but the reduction of the premaxillaries in proportion to the maxillaries would seem to point to another division of the family entirely (e.g., *Talismania*) if one could assume that the relative dimensions of these bones would not also have been changed by such extensive modifications of the entire mouth. In view of the uncertainties about the true basis of comparison with such an aberrant form the exact position of *Mirorictus* within the family Alepocephalidae remains very indefinite.

### *Mirorictus*, new genus

Maxillaries enclosed within the rami of the lower jaw when the mouth is shut. Premaxillaries very small, forming only the transverse edge of the

<sup>1</sup> Papers from the "Dana" Oceanographical Collections, No. 28.

mouth in front. Dentition almost rudimentary, with only a few minute teeth in a single row on premaxillaries and the anterior part of the maxillaries. Teeth absent from vomer, palatines and lower jaw.

Ventrals present, inserted about the middle of the length without caudal fin. Dorsal and anal fins moderate, approximately equal and opposite; pectorals very short, rounded, but with rather numerous rays. Body with moderate, cycloid scales. Distance from dorsal fin to base of middle caudal rays contained less than twice in the length of the dorsal fin base. Head naked. Body fairly slender, compressed. Head moderate or small. Eyes large, normal. Gill membranes normal, not covering pectoral fin base. Branchiostegal rays few (only 4 in genotype). Four gills, opening behind the fourth restricted to lower limbs of arches. No evidence of luminous organs. Pyloric caeca few and simple. Supraclavicular process present.

*Mirorictus tåningi*, new species

The top of the skull is very smooth, with a gently curved profile, and a slightly convex interorbital space. The lower jaw reaches approximately to the anterior margin of the lens. The appearance of the mouth with the lower jaw artificially forced back is shown in Plate I, D and E. A well defined skin fold, which falls within the rami of the lower jaw, extends from the articulation of the lower jaw on each side forward along the upper (or outer) edge of the area covered by the rami of the lower jaw when the mouth is shut. Lateral line pores on body minute or absent, perhaps a few are present anteriorly but are difficult to discern clearly.

The general characteristics of this unusual fish are so fully covered in the generic diagnosis that little more remains to be said beyond a statement of the specific features which can best be expressed by counts and measurements, and in the illustrations.

D.  $18\frac{1}{2}$  A.  $17\frac{1}{2}$  P. 18. V. 8. Branchiostegal rays 4. Pyloric caeca 5. Gillrakers in first arch long,  $5 + 1 + 12$ , the longest about 3 per cent of the standard length. About 66 scales in a longitudinal series from top of gill slit to base of caudal.

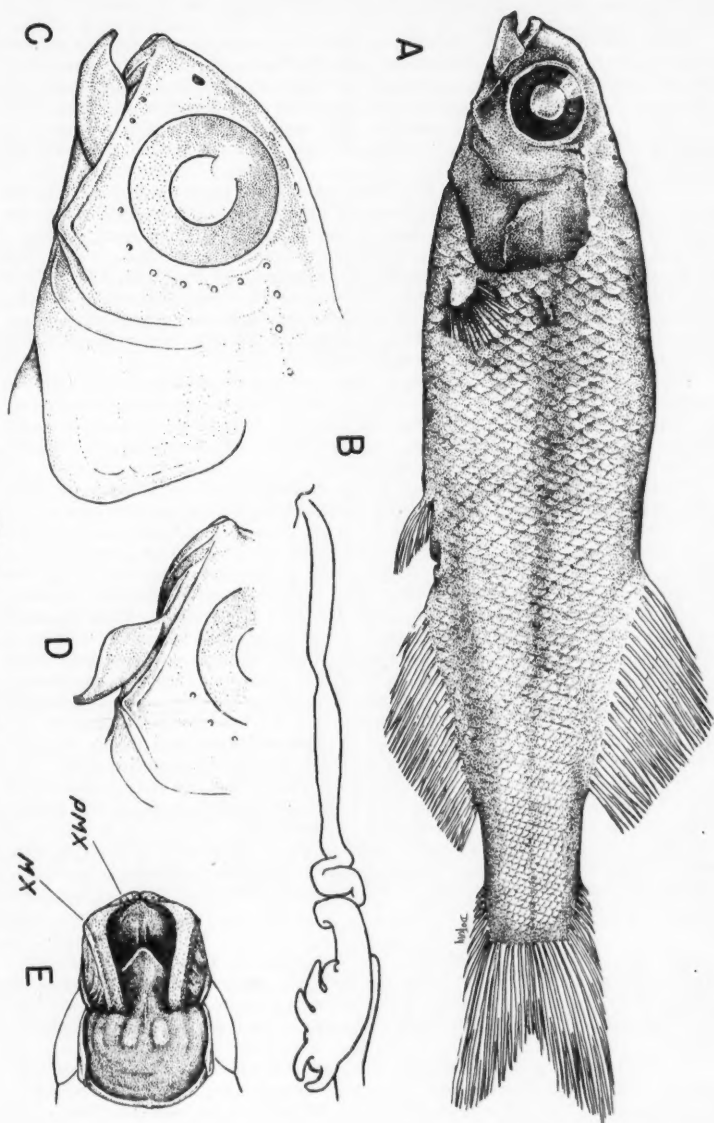
Total length 137 mm. Length without caudal fin 116 mm. Proportions in per cent of this measurement: length of head 27.6; greatest width of skull 12.5; interorbital width 6.0; snout to eye 4.65; diameter of eye 9.8; length of lower jaw 12.1; greatest depth of body 25.0; depth of caudal peduncle 10.3; thickness of body below origin of dorsal fin 7.3; snout to dorsal fin 61.2; snout to anal fin 63.7; snout to ventrals 49.5; base of dorsal 22.8; base of anal fin 20.6; width of pectoral fin base 3.6; origin of ventrals to origin of anal fin 14.2; length of pectorals 6; length of ventrals 10+; longest dorsal ray 13+; longest anal ray 10+; and longest caudal ray 20.

The specimen is very faded, but appears to have been brownish black. Mouth cavity, gill cavity and abdominal cavity dark.

Named in honor of Å. Vedel Tåning.

Type specimen in Dana collection, from station 1209 I, January 17, 1922.  $7^{\circ} 15' N. 78^{\circ} 54' W.$  3500 meters wire out.

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK, NEW YORK.



## Ichthyological Notes

*ESOX AMERICANUS* IN QUEBEC.—While we were making a preliminary survey<sup>1</sup> of the fish and fisheries in the watershed of Lake St. Pierre along the St. Lawrence River between Montreal and Quebec, commercial fishermen of Notre-Dame-de-Pierreville (a village near the mouth of St. François River), described to us a medium-sized fish, which they called "a trout with a pike's mouth." We supposed it to be *Esox vermiculatus*, specimens of which were collected in 1941 in Lake St. Louis by the survey of the "Station biologique de Montréal."

We captured three pickerel at the mouth of a small creek which flows into the St. François River at Abenakis Spring, Yamaska County, on August 24, 1944. These fish (fork lengths 170, 218, and 220 mm.) had red fins and curiously shaped heads, which are short and concave in front of the eyes. Fishermen recognized them as their "trout." Our identification as *Esox americanus* (Gmelin) was confirmed by Dr. R. M. Bailey. Two additional specimens were secured farther upstream in the creek on November 7, 1944. A fisherman sent to our laboratory about 150 specimens. They were captured with hoop-nets (verveux) in Lake St. Pierre, in the great Bay of St. François, west of the St. François River, during the first week of December, 1944.

This is the first authentic record of *Esox americanus* in Canada, and for the St. Lawrence drainage basin. Allin mentioned the occurrence of the species in Lake Erie on the Canadian side (1930, Can. Field Nat., 44: 21). Dr. J. R. Dymond stated in a personal letter, dated January 25, 1945, that "the identification of this specimen was actually an error. The specimen was *Esox vermiculatus*."

The distribution of *Esox americanus* in the St. Lawrence River system is not fully known, since the basin has not been entirely studied. Since 1941 almost 300 seine collections have been taken in Lake St. Louis, Lake des Deux-Montagnes, and a few rivers of the region, especially the Chateauguay River. Only *Esox vermiculatus* has been captured in these watersheds. In Lake St. Pierre, 60 stations have been visited, and no *vermiculatus* were captured. *E. americanus* seems to be confined to this area. It should be emphasized, however, that only the lower part of the St. François River has been investigated. Although it is possible that *Esox americanus* has become established in Lake St. Pierre through stocking, this seems improbable since such an introduction must have taken place long ago. The oldest commercial fishermen state that they have always known the fish, and their fathers knew it before them. Reeve M. Bailey suggests (personal communication) that *americanus* gained access into the Lake St. Pierre area in late glacial time. Then ice still blocked the lower St. Lawrence River, and the Great Lakes discharged their waters to the Atlantic Ocean through a waterway extending south from the St. Lawrence River through the present Lake Champlain basin and Hudson River valley. This waterway presumably permitted the northward dispersal of the species, which still occurs in the upper Hudson River in New York.

I wish to thank Dr. G. Préfontaine under whose supervision the survey has been carried out, and Dr. R. M. Bailey for his comments upon the manuscript.—JEAN-PAUL CUERRIER, Laboratoire d'Hydrobiologie et d'Ichthyologie, Institut de Biologie, Université de Montreal, Canada.

RECORD OF THE TILEFISH, *LOPHOLATILUS CHAMAELEONTICEPS* GOODE AND BEAN, FOR THE GULF OF MEXICO.—An extraordinary extension of the range of the tilefish to the Yucatan Bank in the Gulf of Mexico is based on a specimen recently received from Francis Taylor, who operates a fleet of fishing boats out of Pensacola.

The range of this species as heretofore known is given in *Fishes of the Gulf of Maine*, by Bigelow and Welsh, as from along the continental edge from 69° west longitude, or vicinity of South Channel, southward to the offing of the mouth of Chesapeake Bay in latitude 37° 29' north, in depths ranging from 50 to 200 fathoms with the best fishing in 60 to 65 fathoms.

<sup>1</sup> This survey was made under grants of the Quebec Scientific Research Bureau, Department of Trade and Commerce, Quebec.

The specimen at hand, Museum of Comparative Zoology No. 36454, was caught on Campeche Bank, about 157 miles north by west (true) of Campeche, Yucatan ( $22^{\circ} 20' N$ ;  $91^{\circ} 10' W$ ), in 90 fathoms, February 1, 1946, by the Schr. *Seminole*.

Following is a brief description: Measurements in millimeters—standard length 485; depth 116; head, from snout to end of opercular membrane 158; orbit, rim to rim, horizontal 35, vertical 32; orbit to nostril 18; snout to orbit 62; orbit to end of opercular membrane 77; length of pectoral 136; height of adipose fin 13. Dorsal VII-15; anal 14; scales 99. Anterior border of eye a little in advance of corner of mouth; tip of pectoral reaching almost to origin of anal; color essentially the same as that of a specimen from 35 miles southwest of Nantucket which compares as follows:

Standard length 440; depth 107; head 144; orbit, horizontal 28, vertical 25.5; orbit to nostril 17; snout to orbit 61; orbit to end of opercular membrane 71; length of pectoral 100; height of adipose fin 16. Dorsal VII-15; anal 15; scales 104. Anterior border of eye a little in advance of corner of mouth; tip of pectoral falling short of origin of anal by nearly an eye's diameter.

The Gulf of Mexico specimen differs from that from Nantucket chiefly in having a relatively larger eye (4.5 in head as against 5.1), a somewhat longer pectoral and a slightly lower adipose fin.

These could be attributed to racial differences, and/or size and age.

Dr. Luis Rivas advises us that he has found several instances where a non-migratory species found over an extensive range has, on the average, a larger eye in tropical and sub-tropical waters than in temperate. The length of pectoral and height of adipose appear to become relatively greater as the tilefish increases in size.

Dr. Carl L. Hubbs kindly furnishes the following comparable measurements taken from the type, USNM No. 22899; Standard length 660; head 227; orbit 36; snout to orbit 96; orbit to end of opercular membrane 115.5.

Whether the tilefish occurs in the Gulf of Mexico in anywhere near its abundance off our middle Atlantic and southern New England coasts is not known. However, Mr. Taylor states that local fishermen have taken a number on Campeche Bank and recognize the species sufficiently to call it by the name of "soap fish."

We are indebted to Mr. William Royce of the Fish and Wildlife Service and to Mr. William Ellison of the Atlantic Coast Fisheries Company for sending us specimens of tilefish from off Nantucket and New York for comparison.—HENRY B. BIGELOW and WILLIAM C. SCHROEDER, *Museum of Comparative Zoology, Cambridge, Massachusetts*.

RECORD OF THE ZEIFORM FISH, *ANTIGONIA CAPROS*, FROM THE ATLANTIC OFF BLOCK ISLAND.—Through the kindness of Dr. William F. Royce, Aquatic Biologist, U. S. Fish and Wildlife Service, we have received a freshly preserved specimen of *Antigonia capros* Lowe, family Caproidae. It was captured by the fishing vessel New Dawn, 58 miles south-half-east of Block Island at a depth of 53 fathoms and was landed at New Bedford, Massachusetts, on March 12, 1946. The record represents a northern extension of the known range of this cosmopolitan species. It has hitherto been reported at moderate depths from the Atlantic off the Barbadoes, Azores, Madeira, Ascension Island, Cuba, Brazil, and the North Carolina Coast (Firth, COPELA, 1931: 162) as well as several widely scattered stations in the Pacific.

Fowler (Proc. Acad. Nat. Sci. Phila., 86(1935): 356) described *Antigonia brownii* from a 68 mm. specimen collected in the Atlantic 50 miles southeast of Five-fathom Bank Light Ship off Cape May, New Jersey. It supposedly is separated from *A. capros* by variation in the shape of the dorsal profile, pectoral fin length, and coloration. Such differences might be age variations. So it seems that the determination of the precise status of this species must rest on an examination of additional specimens.

The specimen of *A. capros* at hand resembles rather closely the several published figures such as Müller and Troschel (Horae Ichthyologicae, 1849: 28, fig. 1) and Goode and Bean (Oceanic Ichthyology, 1895, fig. 235) except that ours has a larger eye, 2.8 in head, rather than 3.7 as in the plate. Ribeiro (Archivos do Museu Nacional do Rio de Janeiro, 17, 1915) figures one with a more convex upper anterior profile. The specimen, a female, 114 mm. in standard length and 132 mm. in depth is deposited in the Cornell Fish Collection, No. 10454. After nine days in formalin the color of the body was still

pale red. The entire head is pitted and striated with serrulate rugosities. The head above the eye has a series of radiating striations, the isthmus and chin are rough and the posterior edge of the preopercle is serrate. D. VIII, 34; A. III, 32; V. I, 5; P. 14-14; head 2.6; eye in snout 0.7; bony interorbital in head 3.4, in snout 1.1; distance between posterior nostrils 4.7 in head; lateral line tubes 52; scales above lateral line 15. Cheeks scaled, 10 rows from eye to angle of jaw. Smaller scales on opercles. Dorsal and anal fins scaled at the base. Dorsal and anal spines strongly striated. The third dorsal spine is longest, goes into head 1.5 and into standard length 3.8. The first anal spine is longest in that fin, goes into head 2.1, into standard length 6.3. The tail is mutilated.—EDWARD C. RANEY and ROBERT D. ROSS, *Department of Zoology, Cornell University, Ithaca, New York*.

**EELS FROM THE CARIBBEAN.**—Among the 395 fishes collected for the Chicago Natural History Museum by D. D. Davis and Rudyerd Boulton, on the Mandel Caribbean Expedition of 1940, are the following small eels, caught at night with the use of a light:

*Stillbiscus bahamiensis* Mowbray, one specimen 115 mm., Cayos de San Felipe, Cuba and one specimen 133 mm. from Coxen Hole, Roatan, Bay Islands, Honduras. These two little eels, which are both males with the hearts situated just behind the pectorals (as determined by Miss Betty Storey of the Division of Anatomy, Chicago Natural History Museum), are particularly interesting in view of the fact that Parr (1930) and Trewavas (1932) have suggested that the species may be the male of *Stillbiscus edwardsii* Jordan and Bollman. All known specimens of the species have been caught at night with lights, nine from the Bahamas including the types, and one each from Santa Lucia and Grenada.

*Myrophis macrophthalmus* Parr, one specimen 280 mm., Cayos de San Felipe, Cuba.

*Myrophis dolichorhynchus* Parr, one specimen 178 mm., same locality.

Both specimens of *Myrophis* are in close agreement with Parr's original descriptions and figures (Bull. Bingham Oceanographic Inst., 3, 1930: 9-13).—MARION GREY, *Division of Fishes, Chicago Natural History Museum, Chicago, Illinois*.

## Herpetological Notes

**THE STATUS OF *LEPTOPHIS* BELL.**—Malcolm Smith's (1943, Fauna Brit. India, III: 241) assignment of *Coluber ahaetulla* Linnaeus as the type of the Asiatic snake genus *Ahaetulla* necessitates the application of another name to the genus *Leptophis* Bell. Since there is no available name, I propose the name *Thalerophis* (Gr. *thaleros*, green, and *ophis*, snake). The South American species hitherto known as *ahaetulla* should be called *richardi* (Bory St. Vincent), and it is the type of the genus. The other forms currently recognized (Oliver, 1942, Occ. Papers Mus. Zool., Univ. Mich., No. 462: 1-19) should be placed in the genus *Thalerophis*.—JAMES A. OLIVER, *American Museum of Natural History, New York, New York*.

**EUMECES FASCIATUS IN NORTHERN NEW YORK.**—On August 14, 1939, Herbert W. Shrauer, a former student of mine, collected several five-lined skinks in the Lake George area opposite Hague, New York. They were taken under small logs a half mile north of Camp Sagamore. A large adult was preserved and is now in the Cornell University collection. This record extends the range some 140 air miles north of previous known localities in the state.—W. J. HAMILTON, JR., *Department of Zoology, Cornell University, Ithaca, New York*.



**THE RANGE OF *PSEUDEMYS SCRIPTA GAIGEEAE*.**—Since the description of *P. s. gaigeeae* (Hartweg, 1939, Occ. Pap. Mus. Zool., Univ. Mich., 397: 1-4), several specimens of *Pseudemys* from areas of interest with regard to the definition of the range of this subspecies have come to hand, three collected by the author and Mr. Sam E. Hall, Jr., in Brooks County, Texas, and one from Shackleford County, Texas, collected by Dr. Reeve M. Bailey.

The Brooks County specimens (CM 13484, 13485 (skeleton), and 13640) were taken at a water-hole called Esmeralda on the Alto Coloral section of the A. C. Jones Ranch, between Encino and Agua Nueva, close to the Jim Hogg County line. The two preserved specimens have a slight tendency towards the *gaigeeae* type plastral pattern in the longitudinal lining up of the plastral spots, but are mostly like *elegans* in this respect. CM 13484, a female, has *gaigeeae* type ocelli on the posterior portion of the posterior costals. It also has ocelli on the anterior portion of the first costals. The temporal spot is present but elongated. CM 13640, a male, has the pattern of the head and dorsum obscured, typical of male *elegans* (and perhaps also true of *gaigeeae*, but not of *cataspila*), with dark pigment deposited along the dorsal scute margins, and overlying the head pattern. The temporal spot is much obscured by pigment, but is present and elongate.

The Shackleford County specimen, UMMZ 92727, is very nearly *elegans*, but has an elongated temporal spot. The posterior costals show a very slight tendency to be ocellate. The plastral pattern is of the *elegans* type.

I regard these specimens as intergrades, close to *elegans*, but with affinities to *gaigeeae*.

Hartweg, in the original description, listed Texas intergrades from Reeves, Victoria, and Cameron counties. The Reeves County specimens were closer to *elegans*, except one, almost exactly intermediate. The Victoria ones were almost typical *elegans*, as was the single Cameron County specimen.

Plotting all these on a map indicates that *gaigeeae* is restricted to the Rio Grande drainage in the United States, intergrading with *elegans* to the north. In Mexico it is known only from the Rio Nazas region. It may be deduced that the subspecies is an arid region, northern Mexican form, barely getting into the United States. Its relationships to the east and west can only be conjectured, but intergrades with *cataspila* in Tamaulipas, as listed by Hartweg (*loc. cit.*), and the Cameron and Victoria county specimens may perhaps indicate that in the east, along the Gulf Coast, where conditions differ due to the convergence of Texas rivers at their mouths, and to the presence of coastal swamps and river mouth lagoons behind the barrier beaches which stretch along this coast, *elegans*, and/or *cataspila* intergrades may occur to the exclusion of true *gaigeeae*, due to the capture of these areas by those subspecies. Inland, the area of intergradation seems to begin immediately north of the Rio Grande and to extend to a point somewhere between Shackleford County and, as shown by a specimen of *elegans* in the Carnegie Museum, the headwaters of the Trinity River.

There are also *elegans* specimens in the Carnegie Museum from near the mouth of the Colorado River, but *gaigeeae-elegans* intergrades occur in Victoria County, just across Matagorda Bay. It would appear then, that along the headwaters of the Colorado *gaigeeae* intergrades are found, but along the lower river, near the mouth, *elegans* alone occurs. This would seem to fortify the thesis that along the coast *elegans* and *cataspila* approach each other most closely, forcing *gaigeeae* inland, and forming an area in which all three may perhaps be expected to intergrade at some point. The fact that *gaigeeae*, a water-dwelling turtle, is now found in the most arid regions of the range of the species, indicates that it is the form whose range is being restricted and invaded, and not an incipient invader of the ranges of the surrounding subspecies.

Mr. A. C. Jones (*in litt.*) says that the turtles occur in all the dirt tanks on his ranch, which includes areas in Jim Hogg and Starr counties, as well as Brooks, so that specimens may be expected to be found in those two areas. Small dirt tanks, of the sort referred to, are found on most cattle ranches in the Rio Grande region, and are probably a major factor in the persistence of this animal in the arid region of northern Mexico just south of the Rio Grande.

The intergrades described above, together with those described by Hartweg in the original paper, indicate that the name of the animal should stand as *Pseudemys scripta gaigeeae*, rather than as a full species as in the Stejneger and Barbour Check Lists (1939 and 1943).



I am indebted to Messrs. A. C. Jones and W. W. Jones for many courtesies while a guest on their ranch, and to the former for the information set forth above. Dr. N. E. Hartweg has been very generous with advice, and criticism, and in permitting me to use his notes on his subspecies.—RODGERS D. HAMILTON, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

**THE MOHAVE RATTLESNAKE IN UTAH.**—The Mohave rattlesnake, *Crotalus scutulatus scutulatus*, is reported by Howard K. Gloyd (1940 Chi. Acad. Sci., Spec. Pub. 4: 200) to reach the extreme southwestern corner of Utah, but without citation of records. We have been unable to find any actual older records, but it was ecologically proper to include the corner of the state in its range.

Two specimens in the University of Utah collection now substantiate the occurrence of *scutulatus* in Utah. Both come from the Beaver Dam Slope in Utah, about 6 miles from Nevada and 1 to 3 miles from Arizona; one was taken March 19, 1943; the other March 9, 1946. Both are young snakes bearing only a button without rattles. Both specimens have clear distinct color patterns that fall well within the description given by Gloyd. The dorsal head scutellation, which also falls within the range he described, shows great contrast in the two specimens. One has relatively small scales (with few exceptions) numbering about 60, the other relatively larger plates numbering about 30; the scale rows number 25 and 27; the ventrals 181 and 188; and the dorsal blotches 31 and 36.

*Crotalus scutulatus* has not been found beyond the Beaver Dam Mountains and seems to be limited in Utah to the lower slopes draining into the Beaver Dam Wash. These mountains appear to be the barrier that blocks its entrance into the Dixie Valley farther up the Virgin River, which cuts through the mountain range in a narrow gorge in northern Arizona.—ANGUS M. WOODBURY, *University of Utah, Salt Lake City*, and ROSS HARDY, *Weber College, Ogden, Utah.*

**DESMOGNATHUS F. FUSCUS EATING EGGS OF ITS OWN SPECIES.**—During regular observations of four egg complements of *Desmognathus f. fuscus* Rafinesque, discovered on July 20, 1946, along a spring-fed stream near the Wyomissing Creek, Wyomissing, Berks County, Pennsylvania, I found an adult female of this subspecies with three salamander eggs of the same species in its stomach. My notes follow.

July 20, 1946.—A large slab of rock . . . was lifted and four egg complements of *Desmognathus f. fuscus* were found in excavations in the earth. Each group was guarded by an adult. Approximate number of eggs in each of the four groups from left to right: 28, 36, 7, 17. Beneath the same rock was also found a small *Natrix septemvittata* (231 mm.), which was collected.

July 28, 1946.—Upon elevating the rock only three egg groups were found. Each of these was guarded by an adult. The third complement (mentioned in the July 20th account as having approximately 7 eggs) was missing but a gravid female was in the original excavation. When I proceeded to pick up this specimen it exhibited great ferocity and persisted in trying to bite my fingers. The specimen was preserved for dissection and examination.

July 30, 1946.—On dissection, this specimen is seen to have 9 well-developed ovarian eggs. The stomach contains three salamander eggs still of good shape and color, with well-developed embryos. The envelopes are discernible, and identifiable as those of *Desmognathus f. fuscus*.

Since the ovarian eggs are not quite mature, it is assumed that the eggs found in the stomach of the specimen in question were not deposited by the same individual. I presume that this salamander ate, at least in part, the original complement of 7 eggs.—RICHARD J. BALDAUF, *Mengel Natural History Society, Reading Public Museum and Art Gallery, Reading, Pennsylvania.*

**FIELD OBSERVATIONS ON SPADEFOOT TOADS.**—Late in the afternoon of August 27, 1946, a heavy shower fell 20 miles west of Saltillo, Coahuila, Mexico. No anuran calls were noticed until shortly after dark when *Scaphiopus couchii* Baird and *S. hammondi* Baird were heard calling in the distance.

Collecting along the highway (in company with C. M. Bogert and John A. Moore) for some 10 miles revealed a number of choruses of *S. couchii* but only a single chorus of *S. hammondi*. The *S. hammondi* chorus was in a roadside pond some 200 feet by 40 feet and about 4 feet deep toward the middle; since newly transformed young of *S. hammondi* were found along the edges of the ponds water must have been present for some time. Three mated pairs and about 30 unmated males seemed to comprise the population of the pond. Males were calling both while swimming and while sitting in shallow water. The call was noted as a snore-like cry.

The *S. couchii* were in smaller, shallower pools and in running water in ditches. The choruses were small, varying from one to eight males. As with *S. hammondi*, males were calling both while floating on the water and while sitting in shallow water. The call was noted as a bleat and it was subsequently found that Ortenburger (1924, Proc. Okla. Acad. Sci. 4: 19-20) used the same term in describing the calls of *S. hammondi* in Arizona. Four mated pairs were found.

The completely distinct species aggregations would seem to indicate a high specificity of call response or other factors. To gain some information on this matter, six male *S. hammondi* were placed in a roadside pool and six male *S. couchii* in another pool 96 feet from the first. As soon as the investigator withdrew calling commenced in both pools. Ten *S. hammondi* (8 ♂ and 2 ♀) and ten *S. couchii* (8 ♂ and 2 ♀) were marked by toe clipping and released (2:15 A.M. of August 28) midway between the two pools. A check at 3:00 A.M. showed no *S. hammondi* calling in the *S. couchii* chorus. However, two *S. couchii* were calling in the *S. hammondi* chorus and two more *S. couchii* were calling in a small pool near the *S. hammondi* chorus. One of the released female *S. hammondi* was found clasped by a male *S. couchii* and, in spite of the considerably larger bulk of the male, hopping toward the *S. hammondi* chorus. It is evident that, at least under certain circumstances, *S. couchii* males will proceed away from the calls of their own species toward those of another species. Similar results have been secured with species of *Bufo* (Blair, 1942, Biological Symposia VI: 235-249). It has not been experimentally demonstrated that anurans respond preferentially to the calls of their own species.

Three attempted hybridizations were made in the field, two using *S. couchii* as the female parent and one *S. hammondi* as the female. Two male *S. hammondi* were placed on female *S. couchii* partners at 3:00 A.M. August 28. One female laid shortly thereafter; by 9:30 A.M. the eggs were well along in cell multiplication (64-cell), at 2:00 P.M. they were in yolk-plug stage, and by 9:00 A.M. August 29 they were neurulae. The other female *S. couchii* began laying at 8:00 A.M. August 28; the eggs were in 4-cell stage at 10:00 A.M. and by 2:00 P.M. were in the later stages of cell multiplication. A female *S. hammondi* was pithe and eggs squeezed into a suspension of macerated *S. couchii* testis at 11:30 A.M. August 28. Eggs were in 2-cell stage at 12:15 P.M. and by 3:00 P.M. in yolk-plug stage. The morning of August 29 it was seen that almost all eggs of the three batches had gone bad and the experiment was discontinued.

While handling the toads the night of August 27, the writer found that scratches on his hands became intensely painful. Subsequently he experienced incessant sneezing and discharge from the eyes and nostrils. *Scaphiopus couchii* is believed to be the toad at fault, since Mr. C. M. Bogert related several instances in which handling of this species produced like symptoms. However, there is good reason to believe that the secretions of other species of *Scaphiopus* may have a similar effect. Blair, Hargreaves and Chen (1940, Proc. Soc. Exp. Biol. & Med. 45: 209-214) found that the parotoid secretion of *Scaphiopus holbrookii* irritated nasal mucous membranes, causing incessant sneezing.—A. P. BLAIR, *The American Museum of Natural History, New York, New York.*

**A RECORD FOR MUHLENBERG'S TURTLE.**—A rather large male Muhlenberg's turtle, *Clemmys muhlenbergii* (Schoepff), was caught at Camp Siwanoy, Wingdale, New York, July 7, 1946.

This locality is close to the Connecticut border, which is only one-third of a mile away. There are no records in the literature of Muhlenberg's turtle in Connecticut, and the only record from New England is an old one from Newport, Rhode Island (Pope, Turtles of the United States and Canada, 1939: 104). Jim O'Keefe, the nature director at Camp Siwanoy, tells me that a young specimen of the same species was caught near a stream that flows south from the camp pond, several years ago. I am indebted to John J. Sack, of the Siwanoy nature department, for supplying me with data concerning the more recent specimen.

Between the point of capture and the state line is a pond situated in a shallow valley. On the western bank of the pond the hill rises about 40 yards before it levels off. This level area is a field of grass and short weeds used by the camp. The turtle was found on this field crossing a path and heading west. This point is within 100 yards of the pond.

The measurements (in mm.), in life, are as follows: Length of carapace 93, width of carapace 64, length of plastron 75, width of plastron at widest point 50.—GEORGE D. STEWART, 17 Jackson Street, New Rochelle, New York.

**SONORA SEMIANNULATA SEMIANNULATA IN OREGON.**—On September 11, 1946, a live snake was received from Ontario, Oregon, for identification. A caretul check shows that it is undoubtedly the Arizona ground snake, *Sonora semiannulata semiannulata* (Baird and Girard). There has not heretofore been any published record of the occurrence of this snake in Oregon, despite its having been found along the Snake River in Idaho. A letter from Wayne A. Young, resident biologist of the Oregon State Game Commission, gives the location more exactly. He states that the snake was found about 75 yards from the Owyhee River, some 3 miles south of the backwash of the Owyhee Reservoir. He reports that several other snakes of like markings have been found in the vicinity.

The snake was placed in the same container with a captive northwestern ring-necked snake (*Diadophis amabilis occidentalis*), which I considered to be a safe companion. To my surprise and dismay, the ground snake disappeared less than a week later, and an investigation showed that it had been eaten by the ring-necked snake. The posterior two-thirds of the body were recovered and have been preserved in the department collection.—ROBERT M. STORM, Department of Zoology, Oregon State College, Corvallis, Oregon.

**THE PURPLE SALAMANDER (*GYRINOPHILUS PORPHYRITICUS*) IN QUEBEC.**—In the course of investigating the fauna of a small creek near Iron Hill (about 80 miles southeast of Montreal) on August 25 of this year, a fully metamorphosed male salamander, 175 mm. in length, was secured. Examination revealed this to be an example of the northeastern purple salamander, *Gyrinophilus porphyriticus porphyriticus* (Green).

Dr. Sherman Bishop has kindly advised me that, insofar as he is aware, in Canada the species is known only from the Province of Ontario "opposite Buffalo" (Bishop, 1943, Handbook of Salamanders: 367, map 44). Since these records are twenty years and more old and further instances of occurrence have not been reported, the species must be regarded as rare in Canada. The records from Ontario appear to be based on three specimens, which would seem to corroborate this view.

The specimen in question was discovered beneath a large rock in the centre of a small, fast running stream. The depth of water was about 3 inches, and the maximum depth in the stream at this season would be about 5 inches. Not being aware of the rarity of the species in Canada, an extensive search of the region was not carried out, although about a hundred yards of the stream-bed, which is approximately 2 feet wide, was searched without revealing further specimens.

While the northeastern purple salamander must be regarded as rare north of the United States, the present record from an area so far removed from the northern limits of the known range indicates that the species may be more widespread than hitherto supposed.—CHARLES E. HALL, The National Museum of Canada, Ottawa, Ontario.

## REVIEWS AND COMMENTS

THE FRESH-WATER FISHES OF SIAM, OR THAILAND. By Hugh M. Smith. U. S. National Museum Bulletin 188: xii + 622 pp., 9 pls., 107 text-figs. Washington, Government Printing Office, 1945. \$1.50.—This is the late Dr. Smith's long-awaited work on Siamese fishes, and it forms a worthy monument to a competent ichthyologist. It is, moreover, a very welcome addition to available faunal monographs, since Siam has a very rich fresh-water fish fauna that has never previously been monographed. Indeed, the absence of any sort of review of the complex and difficult cyprinid and silurid fauna existing between the better known and monographed faunas of India, China, and the Malay Archipelago, has been a major stumbling block in Asiatic ichthyology. Dr. Smith's work supplies this need in part, but general works on the fresh-water fishes of Indo-China and the Malay Peninsula are still badly needed.

The manuscript had not been completed by Dr. Smith before his death in 1941, and although Dr. L. P. Schultz has completed the references, there are a number of indications that, had Dr. Smith lived, his wide knowledge of Asiatic fishes would have caused him to add pertinent material and references that would have made the book even more useful. As it is, the work gives keys to the genera and species, and discussions of the latter, but full, formal descriptions are provided only for the new forms. There is a useful general introduction, including a fine gazetteer of fish localities, a section on distribution, and one on the history of Siamese ichthyology. All-in-all, the book is one of the most useful ichthyological treatises of recent years.—GEORGE S. MYERS, *Stanford University, California*.

A DESCRIPTIVE CATALOG OF THE SHORE FISHES OF PERU. By Samuel F. Hildebrand. U. S. National Museum Bulletin 189: xii + 530 pp., 95 text-figs. Washington, Government Printing Office, 1946. \$1.25.—Dr. Hildebrand has again produced a workmanlike faunal handbook that will be of great and continuing use to ichthyologists. The reviewer, for one, wishes to thank the author and to point out how much all biology owes to the patient work of those men who spend a great part of their lives in the unexciting labor of producing plain, unadorned systematic monographs. The experimental biologist, in almost total ignorance of the amount of knowledge, labor, interpretation, decision, and prediction that goes into such work, scorns it, and even the ultra-progressive, "modern" systematist is inclined to push it aside, but the reviewer ventures to predict that works like the present one will, in usefulness and real human value, far outlive those of their detractors.

Dr. Hildebrand gives keys to, and formal descriptions of, all the known families, genera, and species of Peruvian marine shore-fishes. Many are illustrated. There is a brief introduction, the only part of which the reviewer cares to criticize is the statement that "an effort was made to make the catalog so complete that no other books will be required for the identification of the shore fishes of Peru." The book was based chiefly on two collections, each consisting primarily of commercially important fishes, and weak in the smaller forms. This, and the reviewer's own brief shore collecting in Peru, leads him to think Dr. Hildebrand unduly sanguine about the completeness of the work. One month's intensive collecting by a professional ichthyologist on the Peruvian coast would sadly upset this completeness, in spite of the comparative poorness of this cold-water fauna. Thus, *Pinguilabrum*, known to Dr. Hildebrand from one specimen, is not rare in Peruvian tide-pools.

Specialists will notice several lapses, and differ with Dr. Hildebrand on details. For example, the reviewer showed a decade ago that the very peculiar and distinctive genus *Polynemus* is confined to the Asiatic Tropics; no American species belongs to it. Horsburgh's 1935 review of Pacific *Vinciguerra* was apparently not used. *Sarda chilensis* is misspelled, Chabanaud's fine and long continued work on the soles is ignored, and the supposed new species *Ophichthus afueræ* seems to be a synonym of *Pogonophis fossatus* Myers and Wade.—GEORGE S. MYERS, *Stanford University, California*.

**VERTEBRATE PALEONTOLOGY.** By Alfred Sherwood Romer. Second edition: ix + 687 pp., 377 figs. University of Chicago Press, Chicago. 1945.—The classification of all Classes of vertebrates is daily leaning more and more heavily upon the rapidly mounting accumulation of detailed paleontological knowledge, and only the narrowest of specialists on recent vertebrates nowadays fails to make himself familiar with the salient paleontological work on his own group. Dr. Romer's book is the only really up-to-date introduction to fossil vertebrates in any language, and this new edition is indeed a superb summary.

Following a brief introduction, each major group of vertebrates is taken up in one of a series of 25 chapters, illustrated with numerous figures and phylogenetic diagrams. Three chapters then cover the succession of groups through the Paleozoic, Mesozoic and Cenozoic. •Following this, 55 pages are given over to a complete classification of vertebrates, down to families, with mention of practically all known fossil and many recent genera and the geological and geographical range of each. At the end is an exceedingly useful 34-page bibliography, classified by groups, listing all of the most important papers on each group. The 25-page index includes well over 8000 entries.

Specialists will naturally disagree with Dr. Romer on many details, and will find errors in his treatment of their own groups, especially in the vast but compact section on classification. In general, Romer follows Regan's system for teleosts, but reunites all the heterogeneous spiny rayed fishes in the old order Acanthopterygii, and many transitional ones in an order Mesichthys (should be Mesichthyes). Both of these are, in the reviewer's opinion, unfortunate backsteps, due partly to the inability of the author (and he is not alone in this) to comprehend the almost unbelievable variety and fundamental diversity of Cenozoic teleosts, and partly to the still fragmentary though rapidly growing knowledge of earlier, ancestral, Actinopterygian stocks. Also deplored by the reviewer is Dr. Romer's tendency to accept the idea that the armor of some primitive fishlike forms really was primitive, an idea developed by Gregory and others, but which will, the reviewer feels, finally give way before the realization that heavily-armored vertebrate groups have never been the ancestors of anything but creatures very similar to themselves.

Herpetologists will be interested to find the Anura placed as one of three orders under the superorder Salientia, the other two containing tailed beasts now thought to be frog ancestors. Evidently through a lapsus, this usage of these usually synonymous terms is reversed in the text.

Unfortunately, paper shortage caused the utilization of substandard paper, and this has had disastrous results with the new and some of the older, too-finely-stippled illustrations. The older more coarsely stippled ones done by Llew Price held up better, but not too well. These criticisms are, however, minor ones, and will not appreciably hinder users of one of the most useful books on vertebrates ever published.—GEORGE S. MYERS, *Stanford University, California.*

**THE NATURALIST'S LEXICON. A LIST OF CLASSICAL GREEK AND LATIN WORDS USED OR SUITABLE FOR USE IN BIOLOGICAL NOMENCLATURE WITH ABRIDGED ENGLISH-CLASSICAL SUPPLEMENT.** By Robert S. Woods. xviii + 282 pp., Abbey Garden Press, Box 101, Pasadena 16, Calif., 1944. \$2.75.—This book and Jaeger's "Source Book of Biological Names and Terms" (reviewed in *COPEIA*, 1945(1): 57) supplement each other in many ways. Jaeger's is the more inclusive, Woods' the more erudite. Jaeger's is the more superficially useful in finding the meanings of existing names, Woods' the better for learning how to form new ones correctly. If the two authors (both from the Los Angeles region) had collaborated, a really first-class biological lexicon might have resulted. But the reviewer is unable to understand why neither author seems to be familiar with the best brief exposition of the proper formation of classically correct biological names and terms, Miller's "Scientific Names of Latin and Greek Derivation" (*Proc. Calif. Acad. Sci.*, ser. 3, Zool., vol. 1, 1897: 115-143). Biologists who own one or both books would do well to put down a reference to Miller's paper on the flyleaf of their copies.

The majority of systematists and general biologists are so naively ignorant of the principles of word-formation from classical sources that the increasing yearly crop of

stupidly malformed or cacophonous new names (especially generic) sears the soul even of a person who has only the barest rudiments of Latin and Greek. Nor is it only the systematists who err. With such monstrosities as *poikilothermal* (which should have been transliterated *poecilothermal*, and even then doesn't convey what its fond author intended) before us, it is evident that even the general biologist should at least look up such works as those of Woods and Miller before perpetrating nomenclatural indignities upon his more meticulous or informed colleagues.—GEORGE S. MYERS, *Stanford University, California*.

**BIOENERGETICS AND GROWTH.** By Samuel Brody. Reinhold Publishing Corp., New York, N.Y., 1945; xii + 973, many figures and tables. \$10.00.—Although the studies in growth carried on by Dr. Brody and his associates at the Missouri Agricultural Experiment Station have been from the viewpoint of the agriculturist, the principles which they have elucidated apply very neatly to the problems of the aquatic biologist. This book, reporting the results of those studies, discusses the energy cost of maintaining animals, of transforming feed into body tissue, milk, eggs, and other desired products, the relation of the speed with which these transformations occur to the efficiency of the processes, the influence of the size of the producing animal on the efficiency and profit of the productive enterprise, and the influence of the rate of the process on the rate of aging. Many of the factors influencing efficiency, such as enzymes, minerals, vitamins, and hormones, are analyzed, largely with the aid of available literature. These are considerations that fishery men have sadly overlooked in the midst of their preoccupation with such well-tried convenient techniques as scale reading, length-weight curve plotting, length frequency analysis, etc. For these people, this book will prove to be a source of new ideas and a stimulus to new approaches.—L. A. WOLFORD, *U.S. Fish and Wildlife Service, Washington, D.C.*

**ESSAYS ON GROWTH AND FORM PRESENTED TO D'ARCY WENTWORTH THOMPSON.** Edited by W. E. Le Gros Clark and P. B. Medawar, Oxford, Clarendon Press, 1945; viii + 400, several plates and figures. \$6.00.—D'Arcy Wentworth Thompson is one of those few men who are distinguished in many fields. He is a classical scholar, a mathematician, field naturalist, biophysicist, historian. He is perhaps best known to the readers of this journal as the author of *On Growth and Form*, and for his many truly significant contributions to marine biology and oceanography. To honor him on the occasion of his completing sixty years as a professor in the University of St. Andrews, his fellow workers in the field of growth and form have produced as a *festschrift*, a series of essays on that subject. These are "Deformation Patterns in the Cerebral Cortex" by W. E. Le Gros Clark; "Growth and Form in an Insect" by V. B. Wigglesworth; "The History of the Shape of a Nerve-Fibre" by J. Z. Young; "On Biological Transformations" by J. H. Woodger; "Some Problems in the Study of Allometric Growth" by E. C. R. Reeve and Julian S. Huxley; "Size, Shape, and Age" by P. B. Medawar; "The Analysis of Growing Form" by Oscar W. Richards and Arthur J. Kavanagh; "Size and 'Organization in the Development of Ascidians'" by N. J. Berrill; "Growth and Form in Tissue Cultures" by E. N. Willmer; "Some Reflections on the Forms of Simpler Cells" by J. F. Danielli; "The Forms of Biological Molecules" by W. T. Astbury; "Population Analysis as a Chapter in the Mathematical Theory of Evolution" by Alfred J. Lotka, and "A List of the Published Writings of D'Arcy Wentworth Thompson," by George H. Bushnell. The frontispiece is a superb photographic portrait of Sir D'Arcy.—L. A. WOLFORD, *U. S. Fish and Wild Life Service, Washington, D.C.*

**GERMAN FOR THE SCIENTIST.** By Peter F. Wiener. Chemical Publishing Co., Inc., Brooklyn, N.Y., 1946; xxi + 238. \$3.50.—The aim of this book is to help the student to a reading knowledge of German. Part I summarizes briefly grammatical and structural difficulties; Parts II and III give passages from scientific literature. Part IV gives English translations of these passages. There is a vocabulary. The book should prove useful to PhD candidates who have the German hurdle to jump.—L. A. WOLFORD, *U.S. Fish and Wildlife Service, Washington, D.C.*



## EDITORIAL NOTES AND NEWS

### Western Division

### News Notes

THE WESTERN DIVISION of the American Society of Ichthyologists and Herpetologists will hold its 1947 meeting in conjunction with the Pacific Division of the American Association for the Advancement of Science at San Diego. A two-day program, June 18-19, is planned.

THE U. S. FISH AND WILDLIFE SERVICE has announced the initiating of several activities designed to assist in making the Philippines self-sufficient in animal protein foods for the diet of her people. Their program is designed to rehabilitate and develop the fishing industry of the Philippines through (1) scientific investigations in the fields of oceanography, fishery biology, fish culture, food technology and engineering, (2) exploratory and experimental fishing, (3) statistical and economic investigations, (4) market development studies and demonstrations, (5) vocational training in the Islands of Philippine citizens in laboratories and aboard vessels, and (6) training grants in the United States for qualified Philippine citizens in deepsea fishing and other techniques necessary to the development of the fisheries.

HUGH W. TERHUNE has been appointed administrator of the program, with HAROLD T. SMITHER as his administrative assistant. MERRITT BARTON will be marine superintendent, in charge of all marine equipment, vessels and personnel. GILBERT E. WARDELL, now in the Philippines, has been placed in charge of pond-fish management. D. R. GASCOYNE has been named training officer, and is now in the Washington office arranging the schedules and other details incident to the in-service type of training for not more than 125 Filipino trainees prior to July 1, 1950.

The Division of Fishes, United States National Museum has the following ichthyologists working on the following projects at present. DR. S. F. HILDEBRAND, Senior Ichthyologist, Fish & Wildlife Service, is revising the Clupeidae of the Western Atlantic region. DR. LEONARD P. SCHULTZ, Curator of Fishes, and LOREN P. WOODS, Associate Curator of Fishes, U. S. National Museum, are busy working up a report on the 40,000 specimens of fishes from the northern Marshall Islands taken during Operation Crossroads. Mr. Woods has been loaned by the Chicago National History Museum to the National Museum to aid in this investigation. Dr. Earl S. Herald, who with Dr. Schultz, collected the bulk of the Crossroads fishes, is engaged in revising the syngnathids and preparing a report on those taken in the northern Marshall Islands. Dr. Robert R. Miller, Associate Curator of Fishes, is about to return to Guatemala to continue the ichthyological survey of that country, and then work up the material into a comprehensive report. MR. ISAAC GINSBURG, Fish and Wildlife Service, is continuing his work on the American gobies and in addition spending some time on the fishes of the Gulf States. DONALD S. ERDMAN was appointed Scientific Aid in the Division of Fishes, U. S. National Museum on September 16, 1946.

Ichthyologists and herpetologists will be greatly pleased to learn of the appointment on October 15, 1946, of DR. DAVID H. DUNKLE as Associate Curator of Vertebrate Palaeontology in the United States National Museum where he will be actively engaged in working on fossil fishes, reptiles and amphibians.

In letters from Hermann Meinken and Dr. Erna Mohr of Germany Dr. Leonard P. Schultz has received the following information:

DR. ERNA MOHR is Director of the Zoologisches Museum, Hamburg 36. Her fish collection of 250,000 bottles is still underground and all right except for certain parts which were lost. She was working on the syngnathids, centriscids and echeneids in July, 1943, when her house was burned out and they were destroyed. Also the museum building was destroyed.

DR. POPFENHEIM is dead; DR. AHL was at Africa as a soldier and since that time has not been heard from. DR. LADIGES as an old Nazi is no longer an official of the Hamburg Museum. He works at the Munich Zoo at the aquarium. Prof. Dr. MAX



RAUTHER is at Stuttgart, Archivstrasse 3, and PROF. DR. GEORG DUNCKER, Ahrensburg, Holstein, Bismarckallee 51. Both are all right, the latter now in his 76th year and busy working on the Heterosomata.

HERMANN MEINKEN had stored all of his library and scientific materials at Haren on the Ems River. In May, 1945, Haren became a Polish Camp and he lost nearly all of his property including 20,000 reference cards on literature.

DR. MAXIMILIAN HOLLY, former Curator of Fishes, Natural History Museum, University of Wien, now has the address "Wien I, Hetzgasse 23/9, Oesterreich."

A. RACHOW, during bombing, lost all of his property including his ichthyological library, which was totally destroyed.

DR. A. P. ANDRIASHEV of the Zoological Institute, U.S.S.R. Academy of Sciences, had expected to spend about a half-year of the summer and autumn of 1946 as "benthologist" and ichthyologist of an extensive arctic expedition on the icebreaker "North Pole." He hoped to secure interesting supplementary materials on the fishes of the northern seas and from the depths of the polar basin.

Dr. Andriashev lost a considerable part of his library and manuscripts during the battle for Sebastopol, where he was studying the adaptations of fishes to feeding. He is anxious to obtain publications on the systematics, morphology, ecology, and zoogeography of fishes (especially marine), and also general works on oceanography, biogeography, and evolution.

DR. G. J. LINDBERG writes that he is well and again working at the Academy of Sciences in Leningrad following evacuation to Stalinabad, Tadzhik S. S. R., during the war. At Stalinabad he was able to prepare a large amount of manuscript material.

Dr. Lindberg has planned a review of the fishes of the far-Eastern seas, and states that if he were able to obtain material on the fishes of northwestern America (Alaska, Washington, Oregon), he would attempt to widen the scope of this review.

He also writes that he has in press a series of papers on the origin of typical fresh-water fish faunas of the river basins of the seas of eastern Asia. These fish studies have unfolded the history of the Soviet border seas in general and in part of the Pacific Ocean.

The Russian ichthyologists now have on hand a considerable back-log of manuscript material, much of which it is impossible to publish immediately in the Soviet Union, because of the terrific destruction during the war and other urgent post-war needs. They are anxious to publish in American journals, and editors willing to accept such material (in English) may write to Dr. Lindberg or Dr. Andriashev, Zoological Institute, Academy of Sciences, Leningrad 164, U.S.S.R.

Quite fortunately, the main assets of the Zoological Museum, including about 45,000 jars of fish specimens, were saved during the siege of Leningrad.

PROF. I. F. PRAVDIN, Leningrad State University, Leningrad, U.S.S.R., writes that DR. SERGIUS AWERINZEW, who was believed to have been lost during the war (see COPEIA, 1945, No. 4: 239) is alive and working at the Ministry of Fishery Industries. His address is: Ministerstvó Ribnoi Promyshlennosti, Ultize Razina N. 48, Moscow, U.S.S.R.

PROF. B. S. ILVIN is alive and well and is continuing his work. His address is: All-Union Institute of Sea Fisheries and Oceanography, Verkhne-Krasnoselskaya 17, Moscow 140, U.S.S.R.

DR. GORDON GUNTER is acting as Visiting Professor in the Department of Zoology and Research Associate in the Marine Laboratory of The University of Miami. He is working on the Florida spiny lobster investigations and will teach marine ecology and the biology of fishes. He is on leave of absence from the Institute of Marine Science of The University of Texas.

DR. JUSTIN W. LEONARD has returned to his position as Associate Fisheries Biologist with the Institute for Fisheries Research, Ann Arbor, after three years of army service. For over two years he was on a malarial control assignment on Guadalcanal. He is currently engaged in preparing a manual of the trout stream insects of Michigan.

DR. HOBART SMITH has accepted a position with the Zoology Department, University of Illinois, Urbana, Illinois.

DR. E. W. GUDGER WRITES:

"Now that our members are practically all back from military service, I wish them to get this word. I have left over from making the Bashford Dean Memorial Volume lithographed plates of the Segmentation of the Egg of *Bdellostoma stouti*. I also have from my report on the Spotted Sting Ray (*Aetobatus narinari*) to the Carnegie Institution of Washington, plates made from photographs of the just caught fish—authentic portraits.

These will be sent gratis on application to E. W. Gudger, American Museum of Natural History, New York 24, N.Y.

DR. GEORGE MYERS writes that general direction of graduate programs in fisheries biology at Stanford has now been placed in the hands of a Committee on Fisheries Biology, which had been in unofficial operation during 1946. The members are: W. H. RICH (Chairman), F. W. WEYMOUTH, G. S. MYERS, R. L. BOLIN, O. E. SETTE, A. C. TAFT, and J. W. MOFFETT. Dr. Rich, who has been on leave with the Fish and Wildlife Service, returned to full-time duty at the University in September. Dr. J. W. Moffett has been appointed to the honorary lectureship in fisheries vacated by the transfer of DR. RICHARD VAN CLEVE to the International Pacific Salmon Commission.

DR. A. W. HERRE, who held the Curatorship of Ichthyology at the Stanford Natural History Museum from 1928 until his retirement in August, 1946, has been retained by the Fish and Wildlife Service in connection with its program of rehabilitation of Philippine fisheries. Dr. Herre intends to leave for Manila soon. The Natural History Museum Staff tendered a farewell dinner to Dr. Herre upon his retirement.

The "Fischverein," an informal professional discussion group including Stanford and Palo Alto fisheries biologists, ichthyologists and students, which was dormant during the war, was revived last year and is now meeting regularly. About 45 names are now on the list, and recent attendance at meetings has been from 30 to 35. At the December meeting, MR. RICHARD CROKER, Acting Chief of Marine Fisheries, California Division of Fish and Game, who has recently returned from administrative fisheries work in Japan, spoke on his experiences.

The Stanford Natural History Club (formerly the Zoology Club), a student organization remembered by scores of Stanford ichthyological and herpetological graduates since the early nineties, is also holding well-attended meetings and is planning several field trips for the spring.

As of January, 1947, there are 7 students specializing in systematic ichthyology, 12 in fisheries biology, and 2 in herpetology, on the campus or at the Hopkins Marine Station. Of these, 4 are from India, and 1 each from Brazil and Venezuela. Crowding in the Museum building has forced the removal of graduate fisheries students to new quarters in Jordan Hall.

DR. ROLF L. BOLIN, of the Hopkins Marine Station, has been granted a Guggenheim Fellowship and plans to leave in September on a year's round-the-world trip to examine lantern fish collections in foreign museums, preparatory to monographing the family.

Among newcomers to the Stanford campus are DR. MILNER B. SCHAEFER, of the Fish and Wildlife South Pacific Investigations located in Jordan Hall; DR. OLIVER B. COPE and REED S. NEILSON, U. S. Fish and Wildlife Trout Investigation, North Rotunda, Museum Building; and GARTH MURPHY, State Division of Fish and Game, North Rotunda, Museum Building.

RENE NUNEZ, former holder of an Inter-American Fellowship at Stanford University, announces the foundation of the *Instituto de Pesca del Pacifico*, at Guaymas, Sonora, Mexico (Apartado Postal No. 34). He has begun work on the biology of the fishes of the Mexican west coast. The Society suggests that members send Senor Nunez reprints pertinent to his new researches.

THE DIVISION OF FISH AND GAME OF THE TERRITORY OF HAWAII announces the vacancy of a position as Fishery Biologist, grade P-3. The entering salary is \$295.42 plus a bonus of \$45.00, making a total of \$340.42 monthly. There are annual increments, for the first five years of service, until a total of \$362.08 base plus a \$45.00 bonus is reached, giving the maximum salary for this grade under present conditions, \$407.07 monthly. This position is under the Territorial Civil Service Commission.

The minimum qualifications are: (1) a Ph.D. in the field of fisheries or an A.B. in

zoology plus at least 3 years experience in fishery research which must have involved the development of a research project and the preparation of a full report; (2) proven capacity for independent professional work in science.

It is possible that this position could be graded down to a P-2 for a less qualified person or up to a P-4 for one with higher qualifications.

The particular field for which this position was established is that of the reef and shore fisheries of the Territory. From the University of Hawaii the Division of Fish and Game has the use of a 46-foot boat for this portion of the fishery program together with a skilled fisherman-captain of the boat. VERNON BROCK, Director of the Division, writes, "My own feeling about the Hawaiian reef fisheries is that they must be studied not as individual fisheries but more or less as a unit; the reef being the unifying factor. The whole problem offers a fascinating opportunity for the investigation of the ecology of a block of reef and shore fishes. A good deal of underwater field work would be required, and a person who is a strong swimmer and not unfamiliar with shallow diving apparatus would be able to use such talents to great advantage.

At the present time the housing situation is so tight here, that other things being equal, an unmarried man would merit first choice, a married man without children next, and a family man last of all unless he be willing to leave his family for an indefinite time."

THE TULANE UNIVERSITY OF LOUISIANA is considering applicants for a research assistantship in herpetology. Candidate must be eligible for admission to the graduate school and plan to work for the M.S. degree. The accepted student will devote much of his time to field work on a survey of the herpetofauna of Louisiana. Salary \$900.00 for 9 months with opportunity for summer employment. Applicants should write to DR. FRED R. CAGLE, Zoology Dept., Tulane University, New Orleans, La.

DR. ERNEST A. LACHNER, formerly a graduate student at Cornell University, has joined the staff of the Zoology Department of the Pennsylvania State College, State College, Pennsylvania, as Assistant Professor. He is in charge of the work in ichthyology, fisheries management, and fish culture.

DR. L. C. STUART, of the Laboratory of Vertebrate Biology, University of Michigan, left early in February for Guatemala, where he will be engaged in field studies.

ARTHUR M. GREENHALL, former Director of the Portland, Oregon, Zoo, has been chosen by the Detroit Zoological Commission for the newly created position of Chief Technical Director, to be in charge of the Detroit Zoological Park and of the Belle Isle Zoo.

DR. GORDON WALLS, author of *The Vertebrate Eye*, has been appointed Associate Professor of Physiological Optics and Optometry by the University of California, Berkeley.

#### Recent Deaths

ON January 26, 1947, WILLIAM PERRY HAY, 75 years of age, died at Bradenton, Florida, where he had made his home since his retirement in 1934. Though retired, he was far from inactive. For the last five years of his life, he assisted in research work on public health projects at laboratories in Sarasota and Englewood. He was also a member of the editorial board of the latest (Merriam) edition of Webster's *Unabridged Dictionary*.

We learn from SCIENCE of the death, in San Diego, on January 12, of ROSA SMITH EIGENMANN, widow of the late Carl H. Eigenmann, Dean of the Graduate School of Indiana University. Born in 1858, Rosa Smith published her first ichthyological paper (a list of the fishes of San Diego) in 1880, and continued working on the fishes of southern California for several years. Carl Eigenmann came to California in 1886, and there met Rosa Smith. They were married on August 20, 1887, and thereby began an ichthyological partnership which became famous. At Harvard, "Eigenmann and Eigenmann" worked on the Agassiz Brazilian fishes and produced a number of important papers, chief of which was their 500-page review of the South American catfishes, published by the California Academy of Sciences in 1890. Following the year 1893, Mrs. Eigenmann dropped out of formal participation in ichthyological work, although she retained her interest and continued to assist her husband. The last "Eigenmann and Eigenmann" paper, and Rosa Smith's last ichthyological publication, a nomenclatural

note on a South American catfish, *Steindachneridion*, was published in 1919. Among other honors which came to her, Mrs. Eigenmann was the first woman president of Sigma XI.

DR. ERNST SCHWARTZ informs us that OTTO CYREN, Swedish herpetologist, died at Stockholm, Sweden, on September 23, 1946. An obituary and a photograph of him appeared in *Fauna och Flora* (vol. 41, no. 6, 1946).

#### Requests

DR. ANGUS BELLAIRS, Anatomy Department, London Hospital Medical College, Turner St., London, E. 1., England, writes of his needs as follows:

"I read with great interest the extremely generous suggestion that members of your society should send food packages to herpetologists in Europe, and I wonder if I might make a plea on behalf of PROF. J. D. BOYD, the head of this department, and myself, herpetologists both, and keen readers of COPEIA. In contrast with our less fortunate colleagues on the continent of Europe, our physical needs are adequately, if somewhat monotonously catered for at present. On the other hand the paucity of our native herpetofauna deprives us of much mental pabulum which we should like to assimilate. A few kind friends in U.S.A. have already done something to remedy this, but we wondered if we could perhaps make a general appeal through your columns for material that any of your subscribers could kindly spare and send to us.

"Prof. Boyd and I are principally interested in the comparative anatomy and development of reptiles. The type of material that would therefore be most welcome would be reptile embryos of any kind, together with any small neonatal specimens, especially geckoes, amphisbaenids and *Typhlops*. As the material is chiefly wanted for microscopic examination by serial sections, could we suggest that Bouin, Zenker or 5 per cent formalin are preferable as fixatives to spirit—but even spirit specimens would be greatly appreciated. Such material travels quite well in small jars packed in a tin with a little cotton wool.

"We do wish that we were able to offer you something in return—should any of your subscribers require specimens of any of our few reptiles we would be glad to send them. I think I could guarantee any species except *Coronella*, which is very rare. As you know, with currency regulations as they are at present, we cannot even offer to refund the expense of packing and dispatch. So we throw ourselves entirely on your indulgence, save to say that if there is any small service we could do over here for any of your members, we would gladly do our best."

MR. JOHN B. GERBERICH, author of "Annotated Bibliography of papers relating to the control of mosquitoes by the use of fish," writes us as follows: "I am interested in obtaining reprints, copies of unpublished manuscripts and results or observations made in connection with the biological control of mosquitoes. I want to bring this information together in the form of annotated bibliographies."

Mr. Gerberich is on the staff of the Department of Biological Science, Michigan State College, East Lansing, Michigan.

This is an appeal for books and papers on fishes and fisheries and everything connected with them, for our fellow workers in the Philippines. Everything they had was destroyed by the Japanese and all they have now are the pamphlets and books contributed by a few workers and sent over last fall. The need is urgent and anything you can spare will be thankfully appreciated. I shall be leaving for Manila late in April. Anything sent to the address below will be taken to the Islands and turned over to the Philippine workers.—ALBERT W. HERRE, U. S. Fish and Wildlife Service, Room 100—Old Mint Bldg., Fifth and Mission Sts., San Francisco 3, Calif.

#### Erratum

IN COPEIA No. 4, 1946, December 30, in the article "On Taxonomic Questions Related to the Classification of Barbourisia, the Cetomimidae and the Iniomi," by A. E. Parr, in the tenth line on page 262, for "shows" read showed.

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